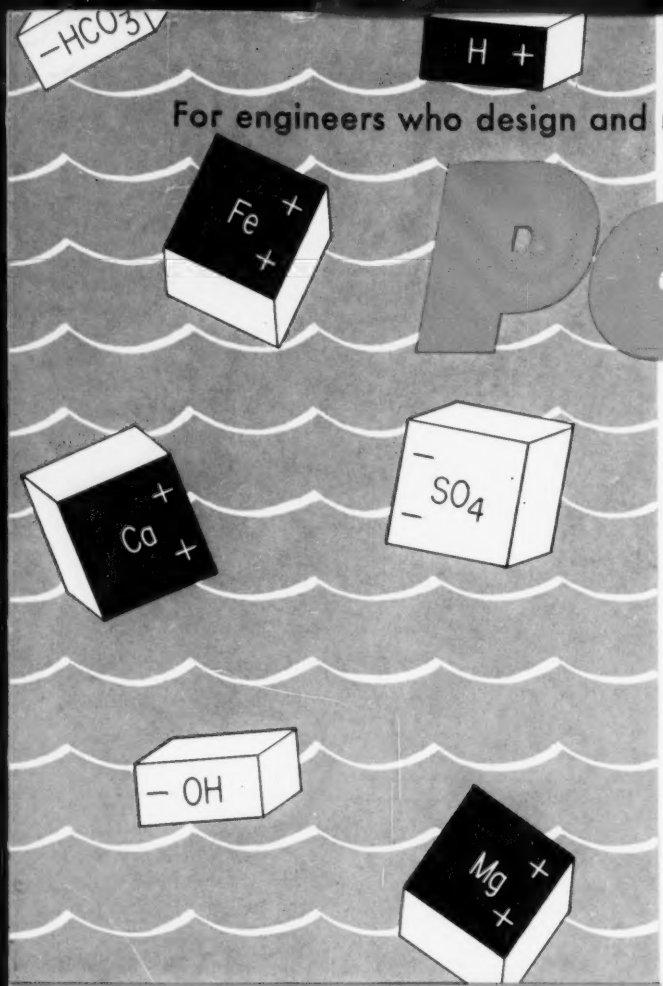

For engineers who design and manage the power and plant services

Power

DECEMBER 1958 • ONE DOLLAR

A McGRAW-HILL PUBLICATION

Figuring fault currents on l-v systems? Use this plan 105

How to squeeze top performance from a h-t water plant 110

Why complete vibration records can be a machine-saver 117

What you can do to quiet noisy in-plant motors 122

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Water Treatment

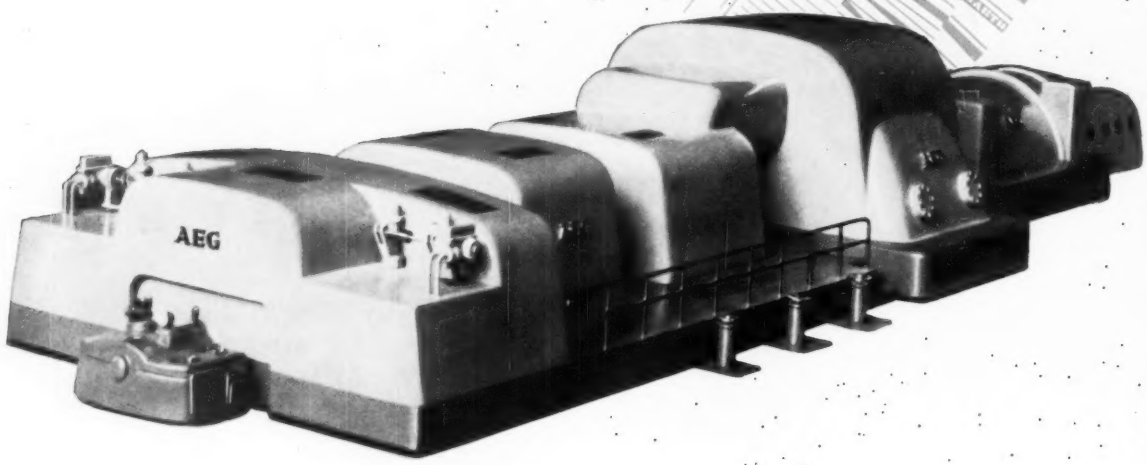
PART ONE

a 32-page special report ▸ 73

AEG

TURBINE-GENERATOR SETS

In 50 years AEG supplied over 5,000 turbine-generator sets up to the largest units with an total output of 25 million kW. AEG's engineering during half a century has contributed to economical power generation and thus for a higher living standard.
AEG are known the world over as pioneers for technical and economic progress.



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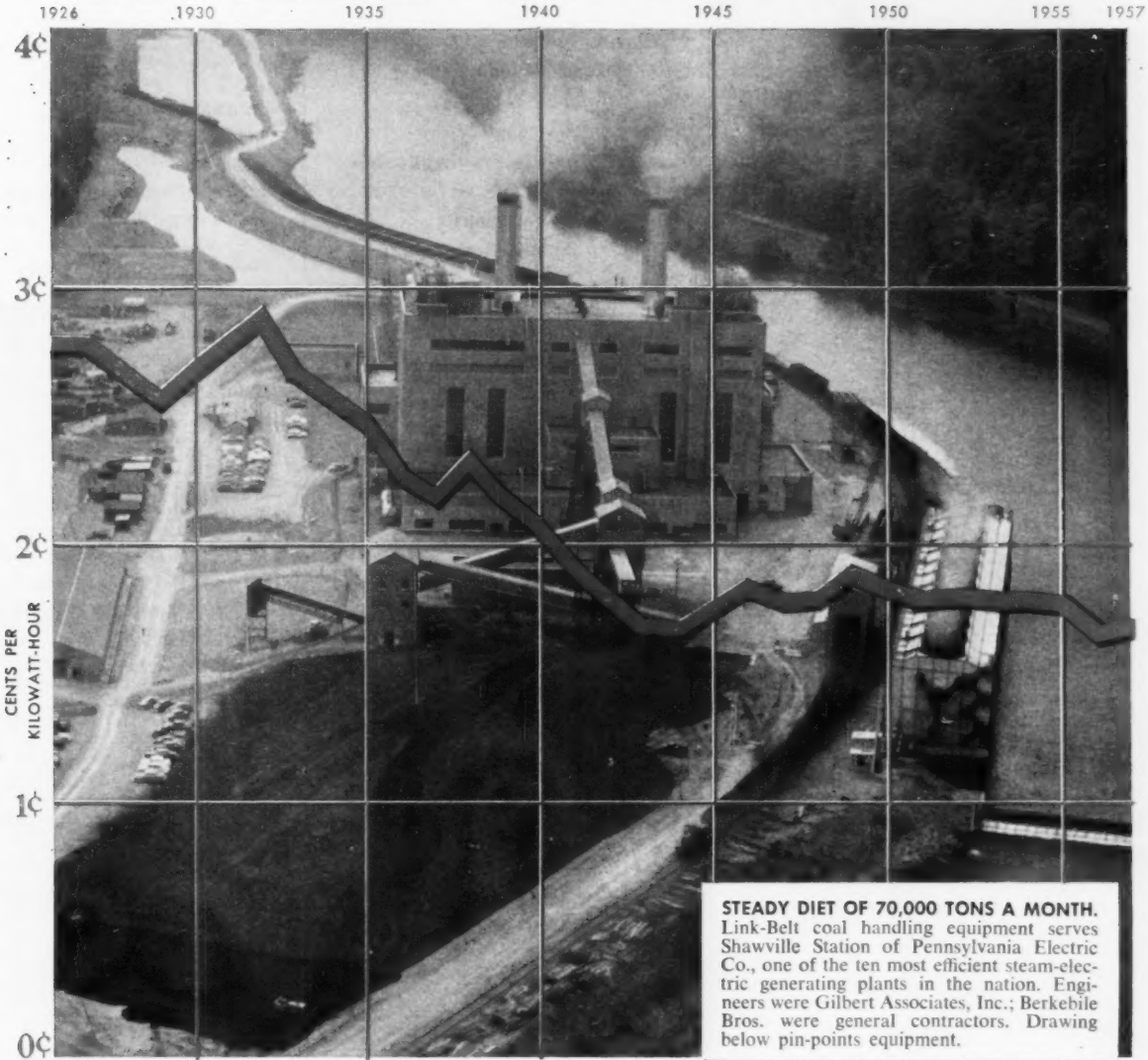
ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

Berlin (West)

Frankfurt (Main)

One "current" cost that's been cut

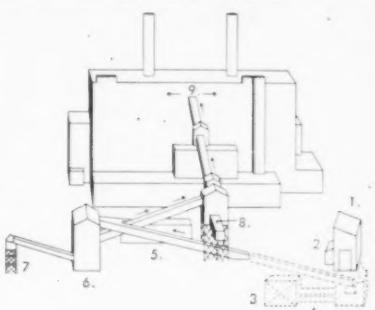


Graph shows national average price per kwhr for all customers of the electric utility industry. Source: Edison Electric Institute.

STEADY DIET OF 70,000 TONS A MONTH. Link-Belt coal handling equipment serves Shawville Station of Pennsylvania Electric Co., one of the ten most efficient steam-electric generating plants in the nation. Engineers were Gilbert Associates, Inc.; Berkebile Bros. were general contractors. Drawing below pin-points equipment.

Low-cost coal handling by LINK-BELT helps lower the price of electrical power

QUALITY-ENGINEERED equipment that handles coal at power plants—through unloading, storing, reclaiming, crushing, sampling, distributing and weighing operations—is an important factor in the cost of producing power. With industry's most complete and reliable line of conveyors and drives . . . plus experience as old as the power industry itself—Link-Belt leads the way to lowest per-ton handling costs. Write to LINK-BELT COMPANY, Dept. AV, Prudential Plaza, Chicago 1, Ill., for our directory, "Link-Belt at Work." You may discover ideas for cutting costs with equipment that delivers extra years of trouble-free performance.



1. Rotary Car Dumper House
2. Car Shaker
3. Truck Hopper
4. Apron Feeders
5. Belt Conveyors
6. Breaker House
7. Refuse Bin
8. Swinging Belt Conveyor
9. Belt Conveyor Trippers

LINK-BELT

One source . . . one responsibility for materials handling, processing and power transmission equipment

14,972

DE LAVAL IMO PUMPS

are now more versatile than ever

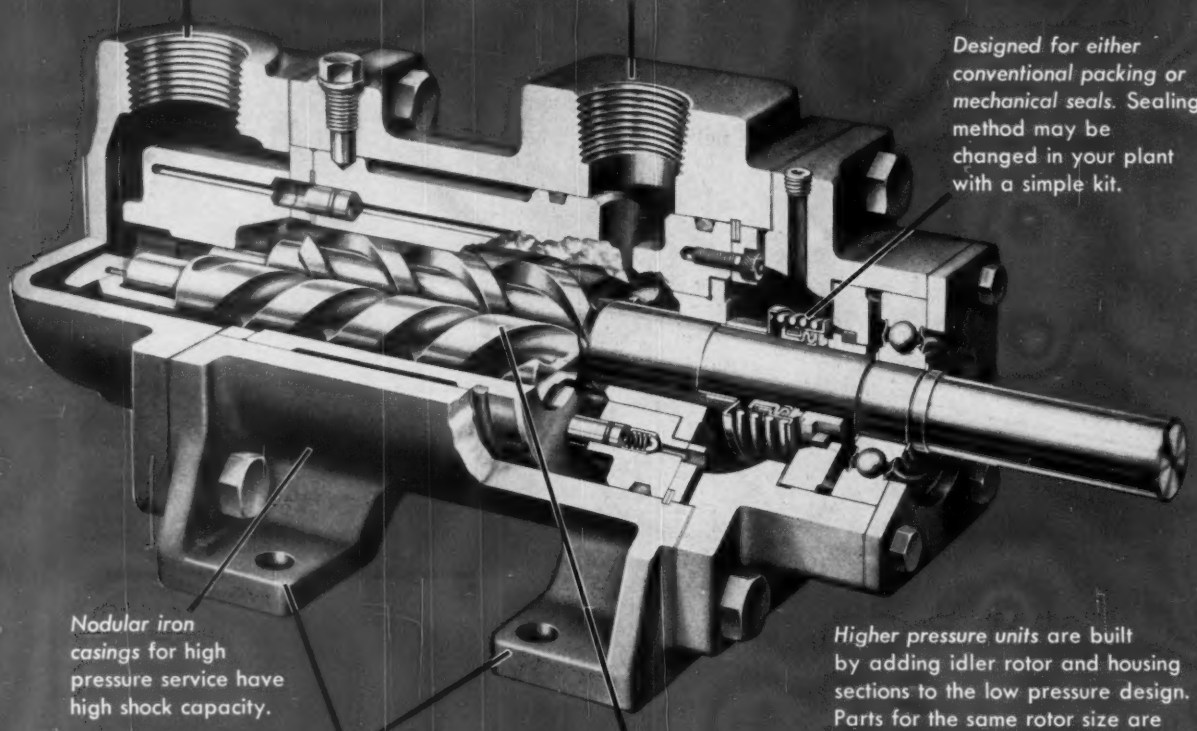
De Laval IMO pumps have proved that they do a dependable job over long years of service. The reason is IMO design simplicity. These constant displacement rotary pumps have only three moving parts—smoothly intermeshing rotors that propel the fluid axially in a steady flow without churning, pocketing or pulsation. There are no timing gears, cams, valves, sliding vanes, or reciprocating parts to wear or become noisy. *Quiet*, compact IMO pumps are excellent for direct-connected, high-speed operation.

In addition to these basic pumping advantages, the improved IMO gives you important new benefits shown in the cutaway illustration below.

Inlet can be rotated to suit installation arrangement.

Discharge flanges are infinitely varied. You can use the most advantageous piping method to suit installation requirements.

DE LAVAL IMO PUMPS can also be used as hydraulic motors.



Designed for either conventional packing or mechanical seals. Sealing method may be changed in your plant with a simple kit.

Nodular iron casings for high pressure service have high shock capacity.

Higher pressure units are built by adding idler rotor and housing sections to the low pressure design. Parts for the same rotor size are interchangeable over the entire pressure range.

Any position mounting is possible without factory modification.

Internal parts are designed as a package so that units can be built into your machines.

Bulletin 3001 gives data on improved De Laval IMO pumps. Send for your copy today.

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY
815 Nottingham Way, Trenton 2, New Jersey

L 418

In Power this month

DECEMBER 1958 • VOL. 102 • NO. 12 • 76TH YEAR

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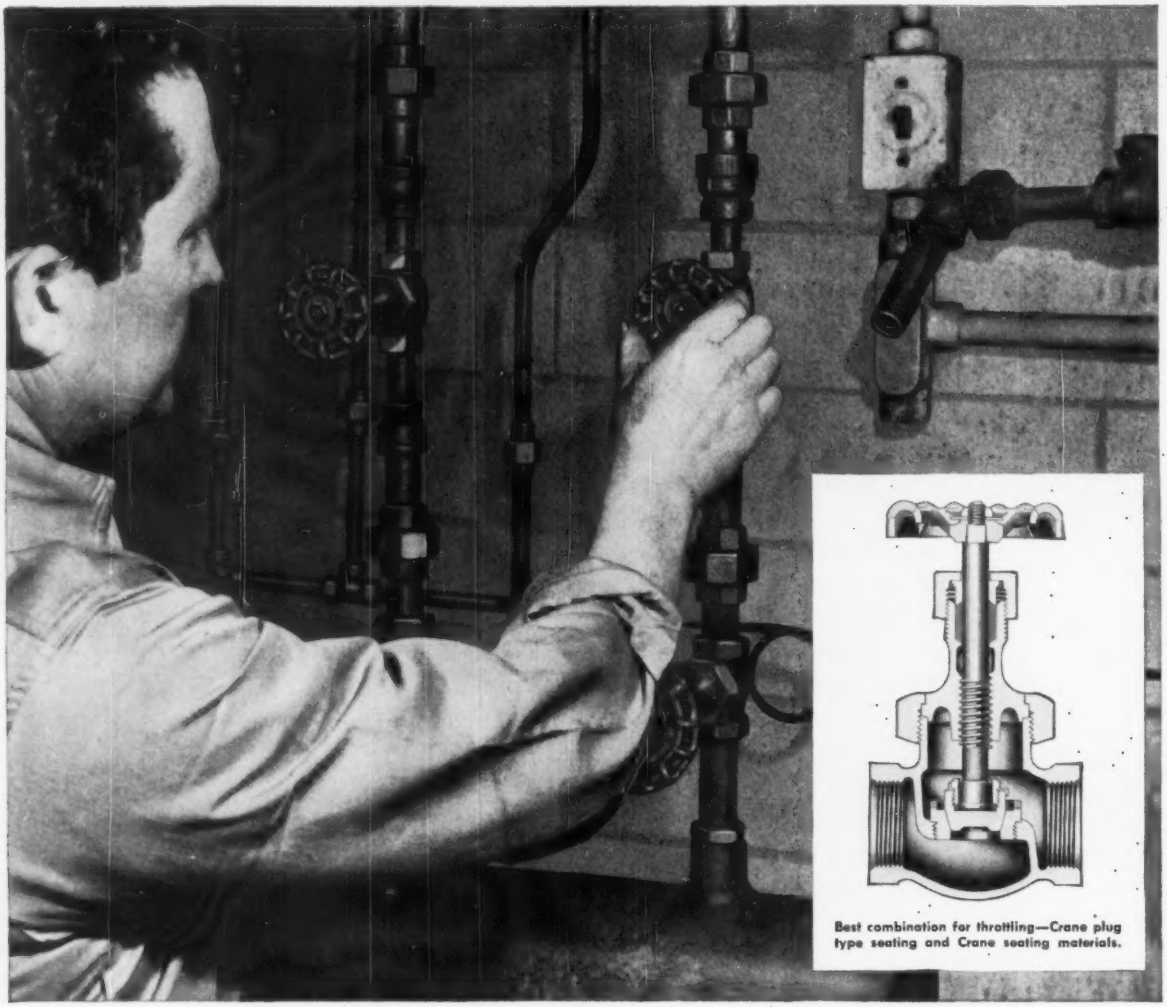

Best combination for throttling—Crane plug type seating and Crane seating materials.

Surprising savings for this power plant with Crane bronze throttling valves

At least once a year, this power plant of a leading machine tool builder was replacing the valves in the ½-inch continuous blowdown lines on its 60,000-pound boiler.

They were high-priced valves, but they couldn't take the continual throttling service. The seats cut out rapidly . . . blowdown regulation was lost . . . valve costs kept rising.

Thirty-one months ago this plant replaced the short-lived valves with Crane No. 212P, 200-pound bronze globe valves with plug type disc. Most of the time these Crane valves have been operating at less than half-open.

Yet, at every inspection to date, they've been found O.K.—no seat damage . . . no loss of regulation . . . no maintenance needed. Another proof of the economy of Crane quality!

To cut your valve and piping maintenance costs—on steam or any fluid—call in your local Crane Man. He has more to offer in money-saving piping materials.

COST-SAVING IDEAS FOR YOU in this free 36-page book of "Valve Performance Facts." Get your copy from your Crane Man or write to address below.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

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W K PONDER — Circulation Manager

speaking of Power

GARRY MOORE, *center,* and TV audience watch electric eel take on load

Off-beat power sources always tickle the fancy of laymen—and engineers. In recent weeks we saw both the electric eel and humble bullock step gingerly into the power limelight.

Electric eel got nationwide viewing when GE's photo lamp dept and the New York Aquarium teamed up for the Garry Moore TV show "I've Got a Secret." Audience saw a Halloween pumpkin lit by eel-watts. Our supplementary-intelligence reporter rounds out the picture with a nugget or two: Seems an electric eel's most effective electrodes are in head and tail. When eel brings these points into contact with an enemy there's enough current circulated to stun the critter.

Bullock is under serious consideration as a prime mover for small pump and generator units (4-5 kw) in Indian villages. Driving mechanism will be two drawbars pulled by bullocks walking in a circle. Early estimate pegs a bullock per kw.

The February issue of POWER will give perspective to new unconventional electric power sources, not however including eels and bullocks. In the form of a *Today's Development* (*TD*) report, Associate Editor Ben Skrotzki will outline latest thinking on many power sources including thermionic converters, fuel cells, solar batteries and advanced thermocouples.

Lou Lowley

Power • December 1958 • Vol. 102—No. 12

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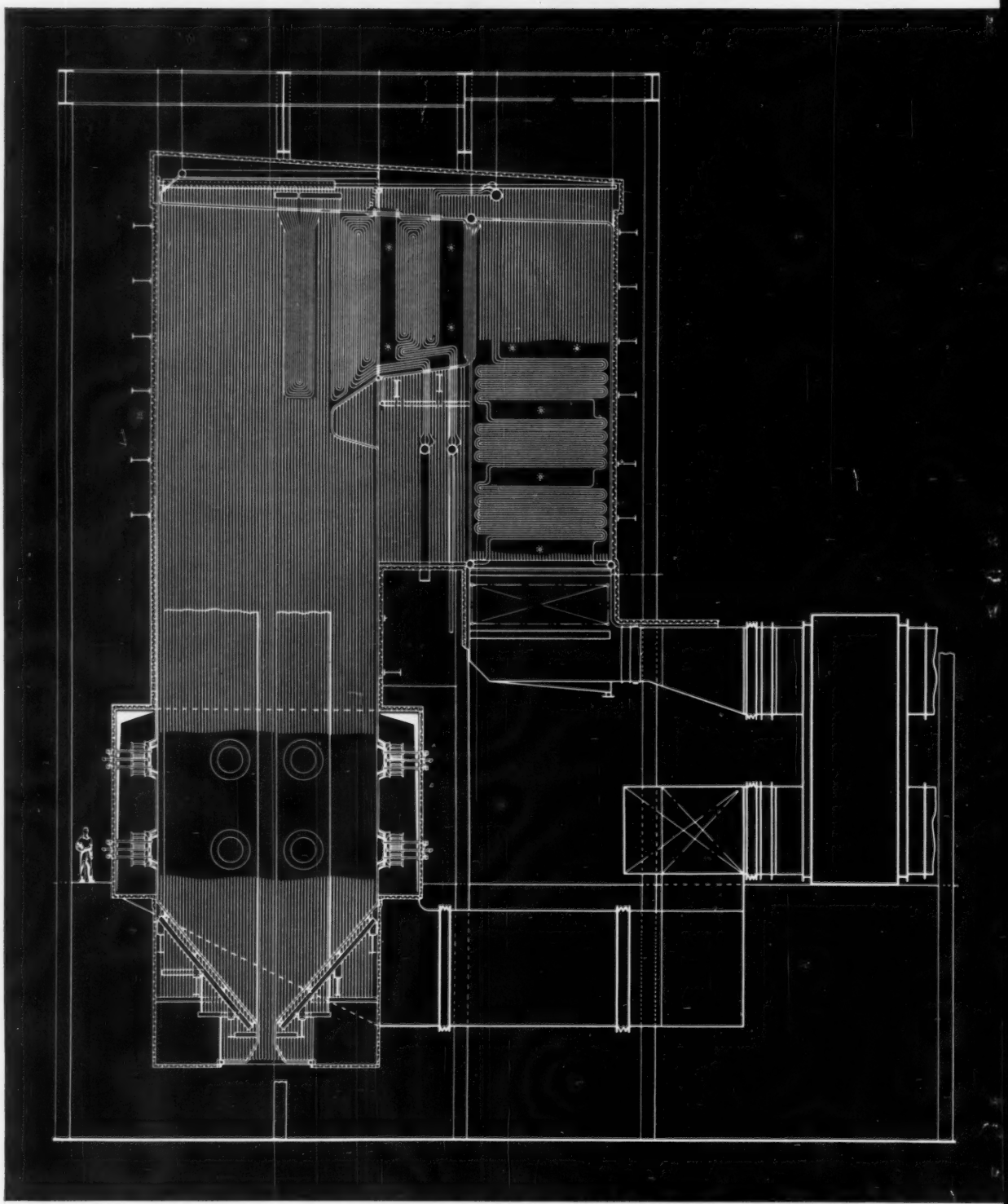
A Big Step Forward–



Newest UP unit for Southern California Edison will provide steam at a rate of 1,638,000 lb per hour to a 210,000 kw turbine at a pressure of 2,400 psi and at a temperature of 1,050/1,000 F. Completion of the unit, which will burn either natural gas or oil, is scheduled for November, 1960.

Why Southern California Edison Purchased B&W Universal Pressure Boiler for 2400 PSI Operation

Once-Through Unit Reduces Capital and Operating Costs —Makes Use of Variable Pressure Possible

A big forward step in holding the line on the cost of producing electricity was taken by Southern California Edison in purchasing two B&W Universal Pressure units for its station at Huntington Beach, California.

Solid savings both in installed first cost and in operation stand behind this decision. Here are the facts:

INSTALLED COST

1. The overall cost of a Universal Pressure Boiler represents a saving over a drum type boiler for identical conditions.
2. Because height and weight of the UP Boiler are much less than those of drum type boilers, there are worthwhile savings in building and construction costs.
3. Superheat, hot reheat and cold reheat steam piping are reduced.
4. Foundation costs reduced because of 650 ton saving in weight of unit.
5. Drum transporting and lifting costs eliminated.
6. One level of stairs, walkways and elevator landing eliminated.

OPERATION

Many significant advantages from the UP's unique operating features helped shape Southern California Edison's decision. Here is what they found:

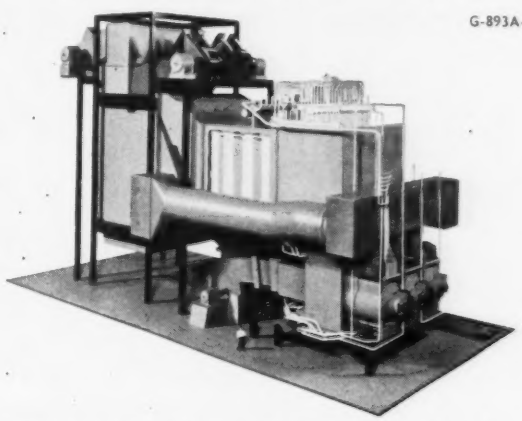
1. Constant steam temperature at all loads without use of tempering equipment.
2. Rapid response to load change.
3. Quick start up and shut down.
4. Simplified control system during normal operation.
5. Minimized operating complications when turbine is tripped.
6. Complete flushing of preboiler and boiler system is accomplished during every start up and shut down.
7. Reduced dependence on safety valves.
8. Elimination of water level gauge glasses and indicators.
9. Ease of acid cleaning.

The Universal Pressure Boiler helps the utilities' pressing need to hold the line on most of the important factors affecting cost of power generation.

Behind its many benefits stands the concrete performance of America's first successful commercial application of the Universal Pressure principle at the Philo Plant of the Ohio Power Company on the American Electric Power System. This unit has had a full year of performance under diversified conditions. Performance, ease of operation and freedom from major troubles have exceeded even the optimum original expectations.

We would be glad to discuss with you the advantages that the Universal Pressure Boiler can bring to your plant. Write to The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

G-893A-CS

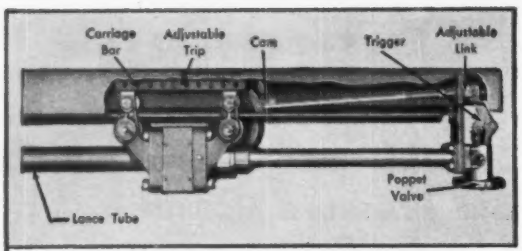


Model of the first Universal Pressure Boiler, which is now operating, uses once-through principle by which water, under pressure, is forced in one end of the system and emerges at the other end as superheated steam. This principle eliminates need for a drum.

BABCOCK & WILCOX

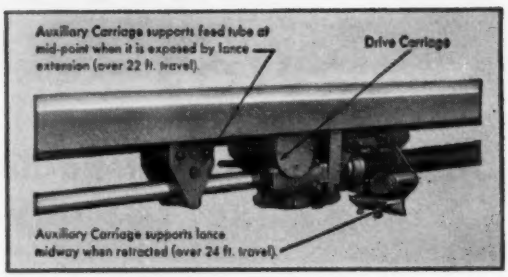
BOILER DIVISION

Reasons FOR THE ENTHUSIASTIC ACCEPTANCE



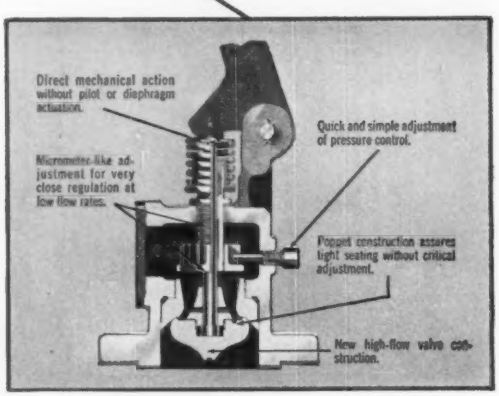
MECHANICALLY OPERATED VALVE

Control of blowing medium is automatic, positive and accurate by means of a simple, dependable mechanically operated valve. As lance begins movement into boiler, trip on carriage opens valve through a linkage. At end of retraction, trip closes valve. All pilot or diaphragm valve elements are eliminated. Trip is adjustable.


Auxiliary Carriage supports feed tube at mid-point when it is exposed by lance extension (over 22 ft. travel).
Drive Carriage
Auxiliary Carriage supports lance midway when retracted (over 24 ft. travel).

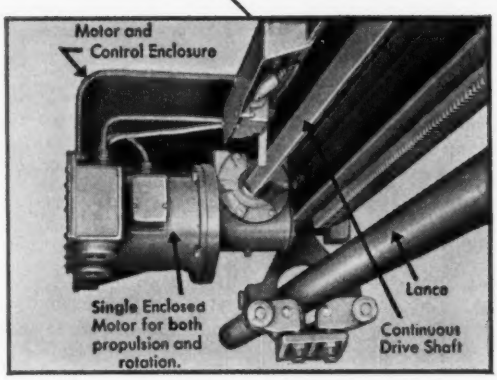
AUXILIARY CARRIAGES (FOR EXTRA LONG TRAVEL)

On extra long blowers, one auxiliary carriage supports lance midway when retracted, preventing undue bending. Second auxiliary carriage is dropped at mid-point to support feed tube when it is exposed by lance extension.


Direct mechanical action without pilot or diaphragm actuation.
Micrometer-like adjustment for very close regulation at low flow rates.
Quick and simple adjustment of pressure control.
Poppet construction assures tight seating without critical adjustment.
New high-flow valve construction.

POPPET VALVE WITH ADJUSTABLE PRESSURE CONTROL

Diamond dependable poppet valve with improved streamlined flow contours and adjustable pressure control that permits easy, accurate setting of pressure at individual valve and independent of other blowers. Poppet construction assures tight seating without critical adjustment. Stem, seat and disc are stainless steel. Stellited seating surfaces are available.



STATIONARY GEAR MOTOR

Lance propulsion and rotation are by a *single* enclosed gear motor which drives a continuous shaft running the full length of blower and providing power to carriage. This construction makes it possible to mount motor in a fixed position at the front end for better protection and accessibility.

8077

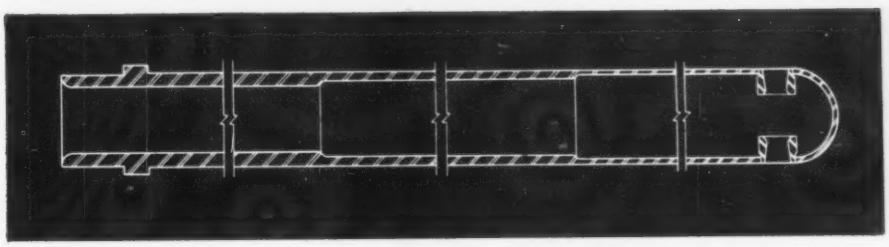
Diamond

DIAMOND POWER

of the DIAMOND SERIES 300 IK
LONG RETRACTING BLOWER

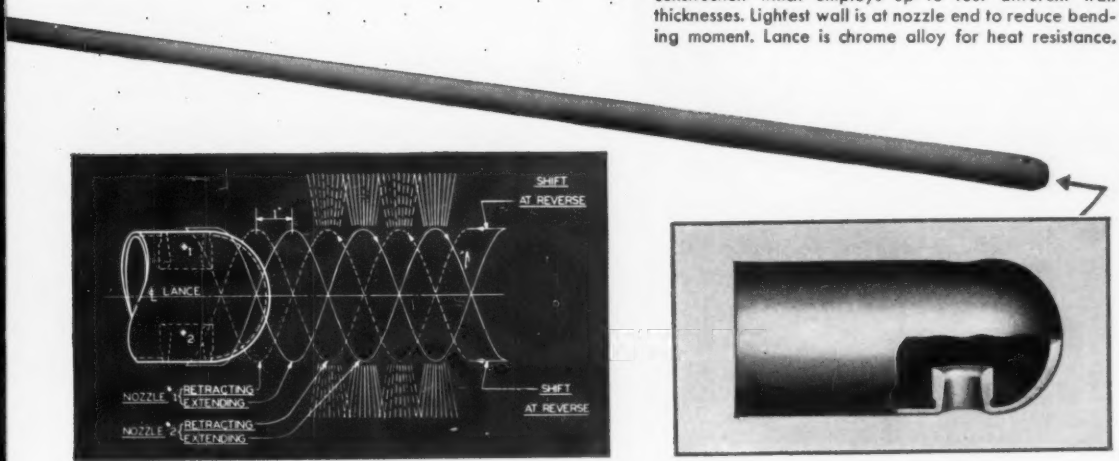
The Diamond Series 300 IK Blower sets a new and higher standard of efficiency, economy and dependability in the cleaning of heating surfaces that require a long retracting lance type blower. Pointed out in detail are some of its important features. Others are a *single* outboard support point to simplify installation and the attractive "backbone" cover for greater rigidity and protection of the entire blower assembly from dirt, damage, the elements and personnel hazards.

This new Series 300 IK is the culmination of more than 20 years' experience building and applying long travel blowers. It well illustrates the Diamond design philosophy: *"Keep it simple . . . keep it basic . . . avoid unnecessary complications."* It is further evidence of the fact that YOU CLEAN BOILERS BETTER AND AT LOWER COST WITH DIAMOND BLOWERS.



STEP-TAPER LANCE
(FOR EXTRA LONG TRAVEL)

Extra long lance has minimum droop due to step-taper construction which employs up to four different wall thicknesses. Lightest wall is at nozzle end to reduce bending moment. Lance is chrome alloy for heat resistance.



IMPROVE CLEANING PATTERN

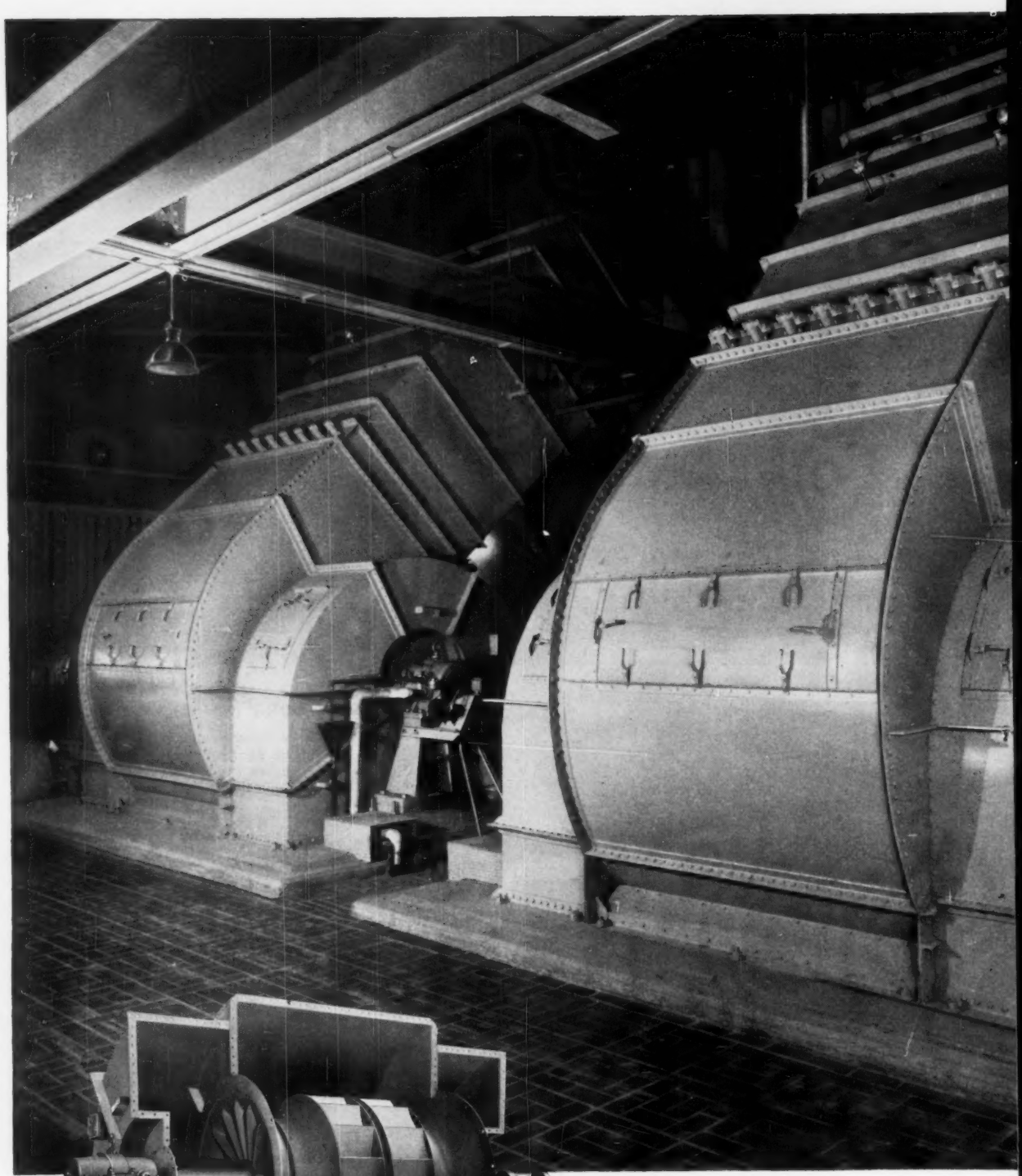
Close and positively controlled helical cleaning pattern assures maximum cleaning effectiveness. Blowing pattern diagram illustrates how return travel path is exactly intermediate with forward travel path so that there is a *positive nozzle sweep every inch.*

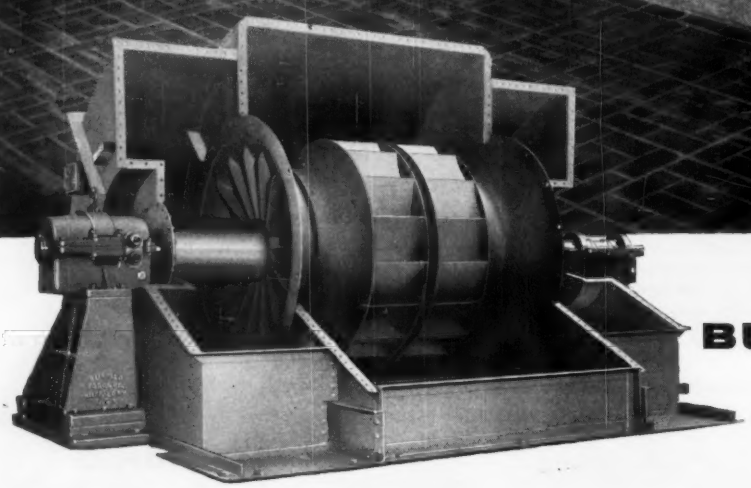
IMPROVED DIAMOND NOZZLE

New design Diamond "Type A" Nozzle is the result of several years' research and the testing of more than 50 different contours. The modified venturi produces maximum impact pressure and cleaning effectiveness with minimum expenditure of cleaning medium. (Steam or compressed air.)

For further information, ask the nearest Diamond office or write directly to Lancaster for Bulletin 2111U.

SPECIALTY CORP. **LANCASTER, OHIO**
DIAMOND SPECIALTY LIMITED—Windsor, Ontario





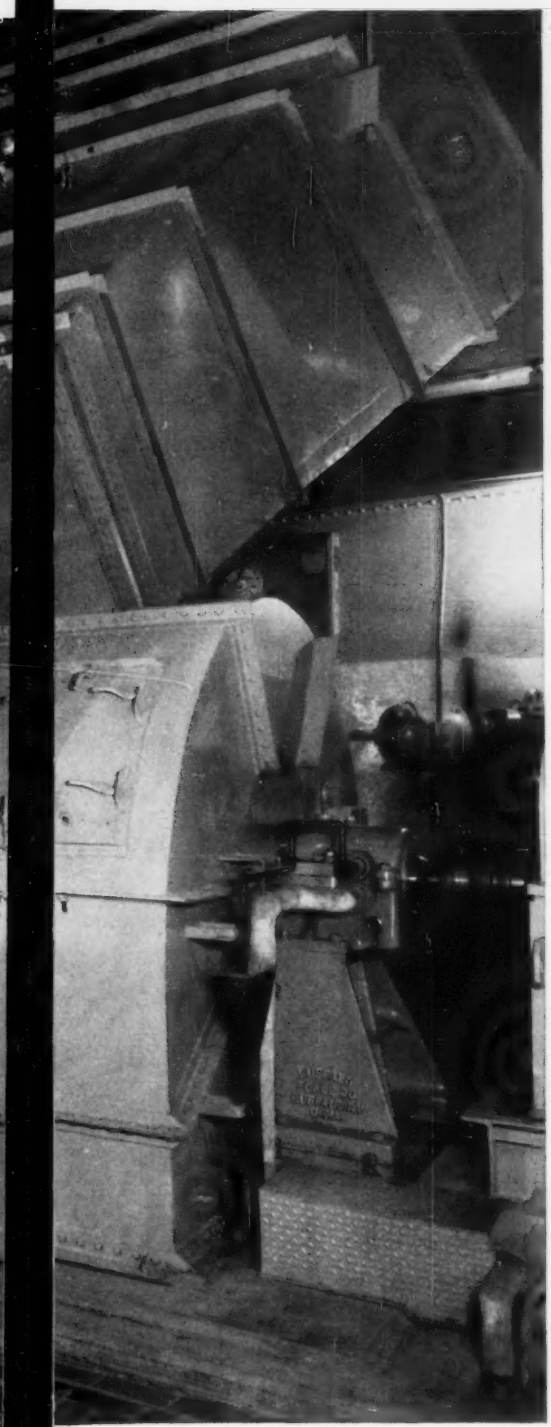
BUFFALO FORGE

BUFFALO,

BUFFALO PUMPS DIVISION

Canadian Blower & Forge Co., Ltd.,

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT



WHY YOU GET MORE AIR PER HORSEPOWER WITH "BUFFALO" AIRFOIL FANS

COMPLETELY STREAMLINED INLET. Wheel flange and matching inlet bell form true half-circle, eliminating turbulence causing flat spots. GENEROUS INLET BOX DIMENSIONS give lower loss through inlet boxes than competitive makes, thus smoother air entry. VARIABLE INLET VANES, when used, are placed well into the inlet throat. Horsepower-reducing spin developed by the vanes is therefore fully utilized by the wheel. WHEEL DESIGN incorporates proper blade passages and air-flow through the wheel, in addition to airfoil blading, to produce maximum efficiencies. SCROLL shape lets air stream from blade passages to the housing channel with greatest ease. DIVERGENT OUTLET provides the optimum of static regain as the air passes from the cut-off, insuring the most efficient performance. Conventional outlet fans have a considerable amount of turbulence at this point.

BUFFALO AIRFOIL FANS ARE BUILT TO:

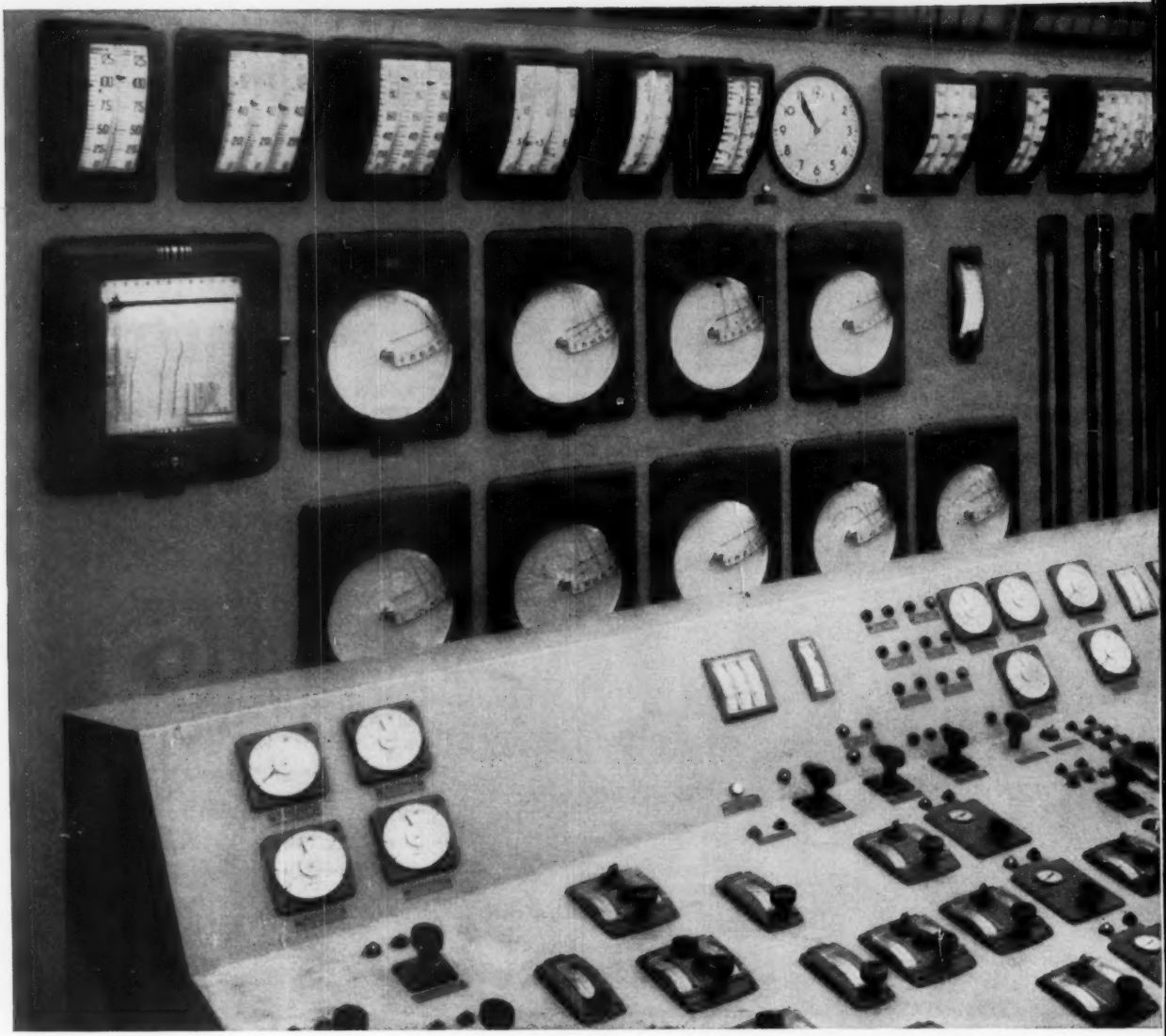
- Capacities in excess of one-half million cfm
- Pressures of 80″ water
- Outlast all other airfoils*

COMPANY
NEW YORK
BUFFALO, N. Y.
Kitchener, Ont.

"Buffalo"

*Every Buffalo Fan brings you the extra benefits of the famous "Q" Factor construction — the built-in QUALITY that assures trouble-free satisfaction and long life.

EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING



How Bailey puts, at your finger

Concentrated, here, in one centralized control room are all the meters and controls needed to operate a Cyclone Furnace Boiler. Bailey puts them at your finger tips. Makes operating duties a pleasure. Increases plant efficiency.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

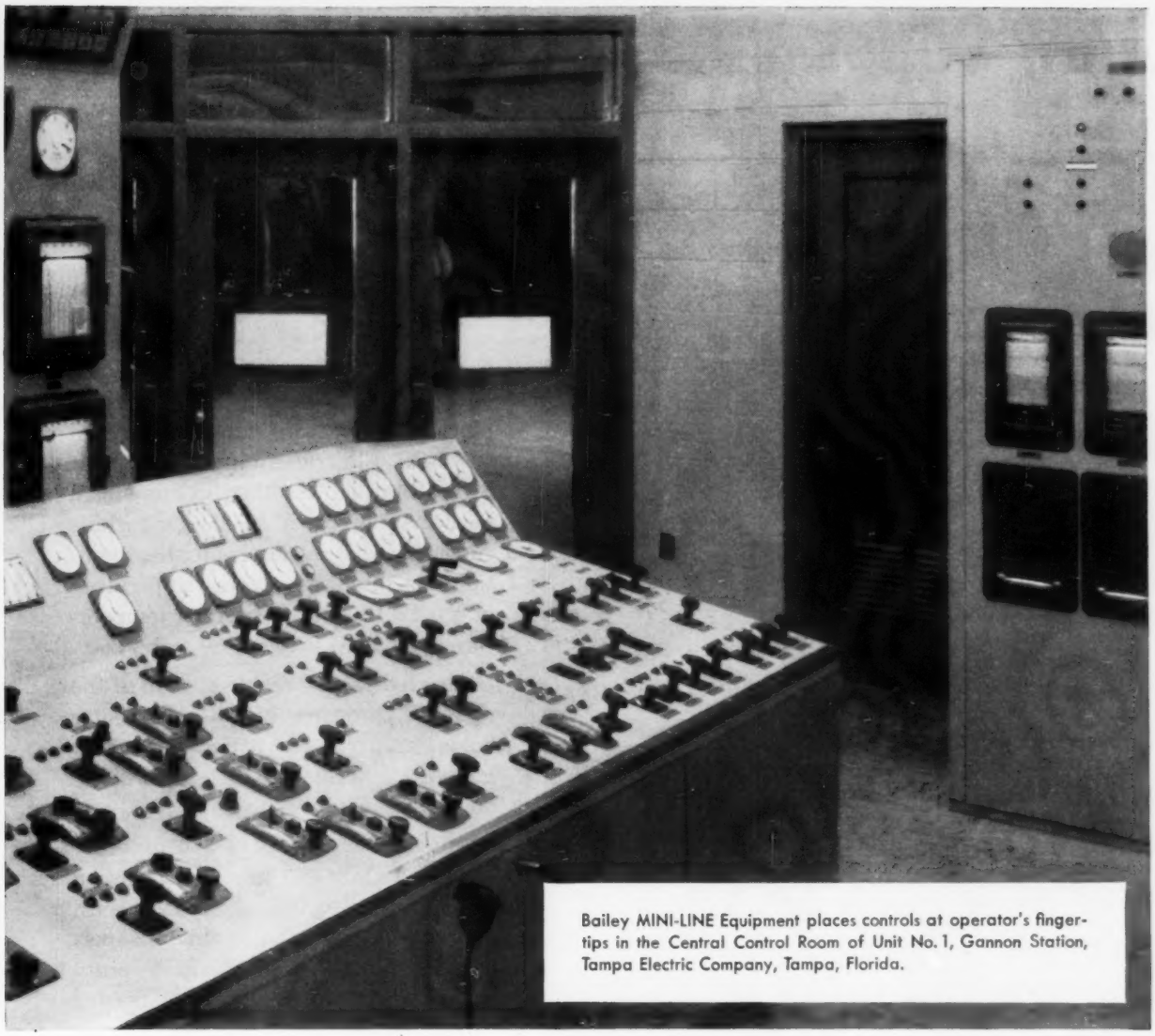
1. A Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs.

Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems of measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work efficiently for more than forty years. Veteran engineer and young engineer alike, the men who



Bailey MINI-LINE Equipment places controls at operator's fingertips in the Central Control Room of Unit No. 1, Gannon Station, Tampa Electric Company, Tampa, Florida.

tips, controls for STEAM PLANTS

represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your particular problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering counsel on your steam plant control problems.

A137-2

Instruments and controls for power and process

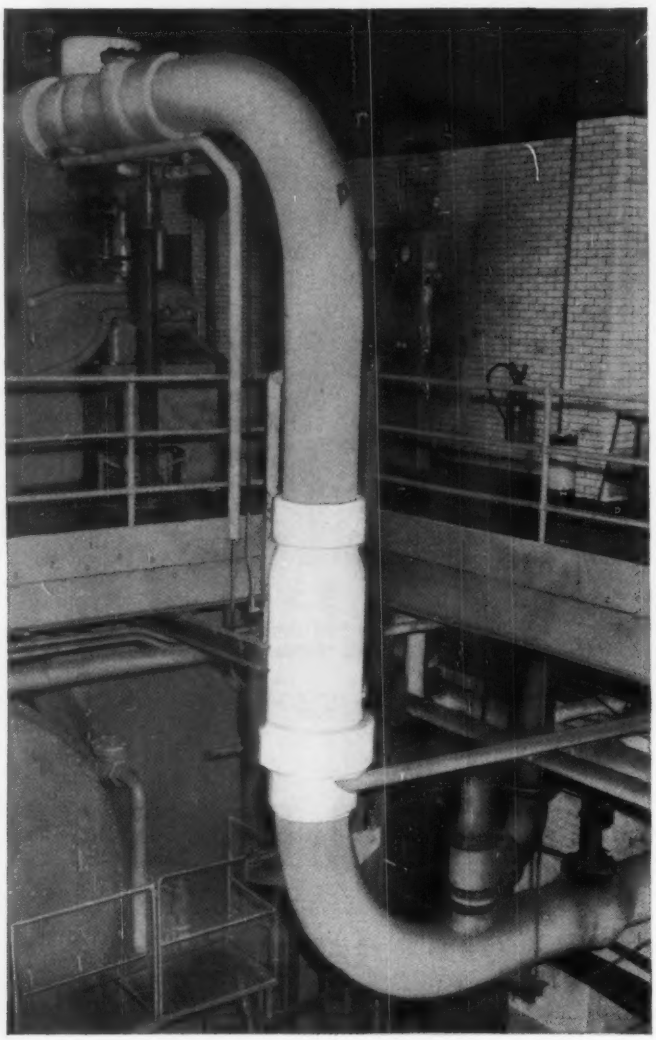
BAILEY METER COMPANY

1036 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

BAILEY METERS

New Copes-Vulcan Desuperheater handles critical job at Pennsylvania Electric Company



Copes-Vulcan's newly developed Variable-Orifice Desuperheater provides precise temperature control at Pennsylvania Electric Company's Front Street Station. Installed in the steam header supplying a 12,500-kw turbine generator, this desuperheater has maintained a discharge steam temperature of 490 FFT even though inlet temperature has varied between 600° and 650°.

Located just 20 feet upstream of the turbine throttle this desuperheater holds temperatures within a plus or minus 3F limits, consistently meets all required pressure conditions.

Advance design pays off in other ways, too. Only one outside connection —for cooling water—is needed. With only one moving part, this desuperheater presents no maintenance problem. No long runs of piping are needed to mix fluids. No atomizing steam, spray nozzle or glands are required.

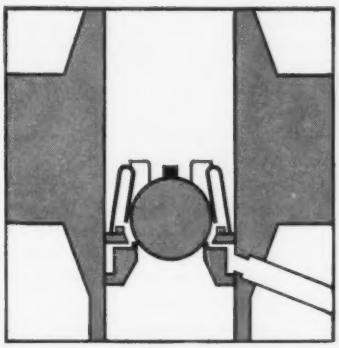
Copes-Vulcan designs a complete line of desuperheaters, each type engineered to meet particular operating conditions. For complete details on the Variable-Orifice Desuperheater, write for Bulletin 1037.

COPES VULCAN

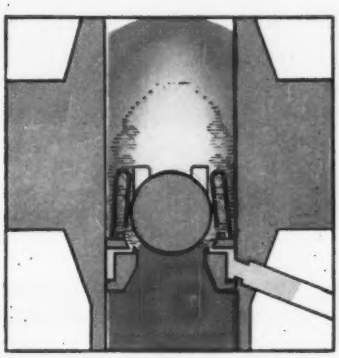
Copes-Vulcan Division
BLAW-KNOX COMPANY
Erie 4, Pennsylvania

BLAW-KNOX

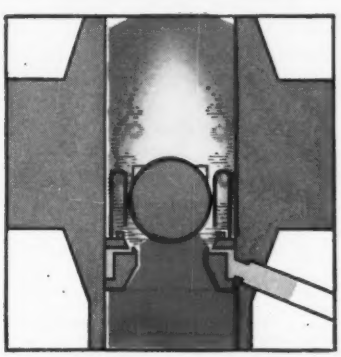
SIMPLE PRINCIPLE OF OPERATION



No load: Ball has seated itself on the ring. There is no flow of steam—no flow of cooling water.

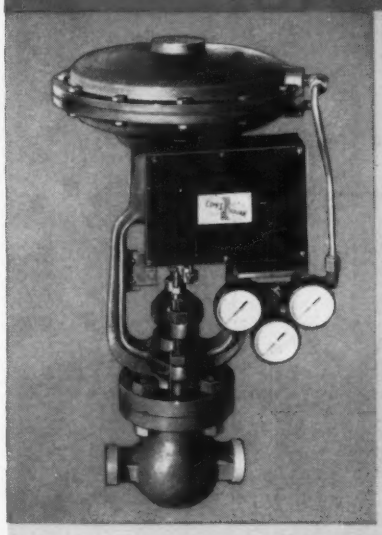


Light load: Ball opens orifice slightly. Cooling water is instantly and intimately mixed with steam.



Full load: Orifice fully opened. There is the same pressure drop and high turbulence at all loads over the full range.

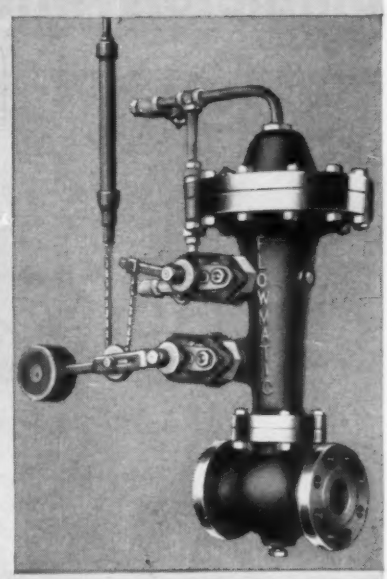
C-V NEWS NOTES



A Type CV-D Pressure reducing valve is used at Front Street Station to automatically regulate the cooling water supplied from the feed-water-heater.

This Copes-Vulcan diaphragm valve is designed to dependably meet rigid standards of accuracy for pressure, temperature and liquid level control. The Type CV-D may be direct or reverse acting. Rangeability is excellent.

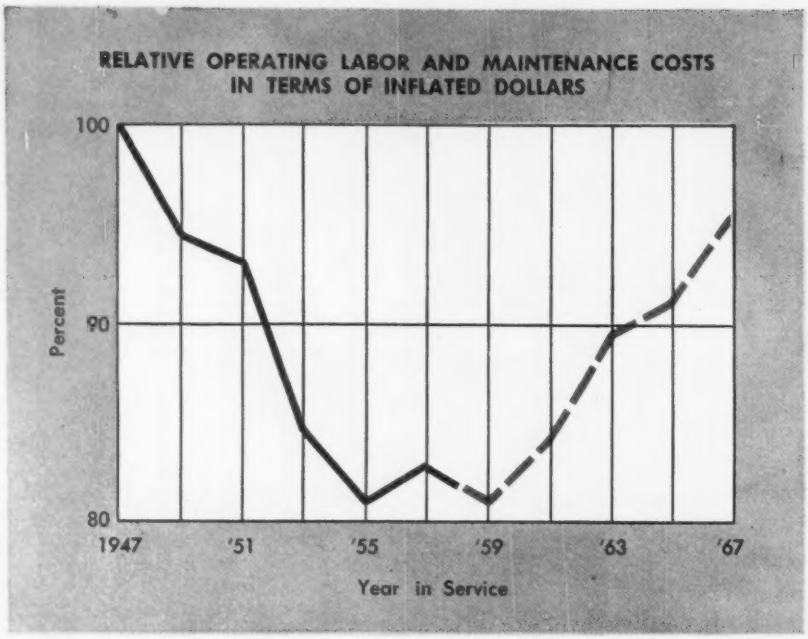
Style and area of valve ports are scientifically selected to meet specified operating conditions. These versatile valves can be applied in sizes up to 12 inches in pressure—standards up to 1500 pounds. For details on Copes-Vulcan valves, write for Bulletin 1027.



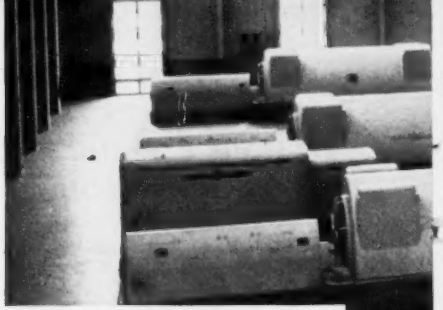
For modern feed water control: The Copes Flowmatic, a two-element feed water regulator, is sensitive to the slightest change in steaming rate, and to the most minute fluctuation of boiler water level.

Closer stabilization of boiler water level under all load conditions makes the Copes Flowmatic ideal for the modern utility and industrial boilers subject to rapid, wide fluctuations in steam demands.

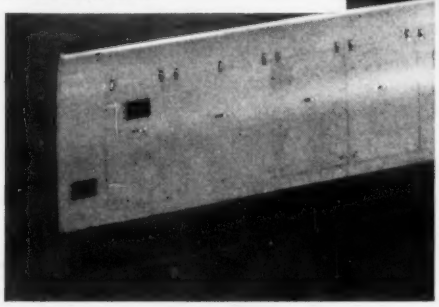
With the direct-operated Flowmatic Regulator (shown above) the steam flow element is built integral with the valve bonnet. In regular service outdoors, the Flowmatic Type D-O is unaffected by atmospheric conditions, provides accurate, dependable performance. For further information, write for Bulletin 1003-A.



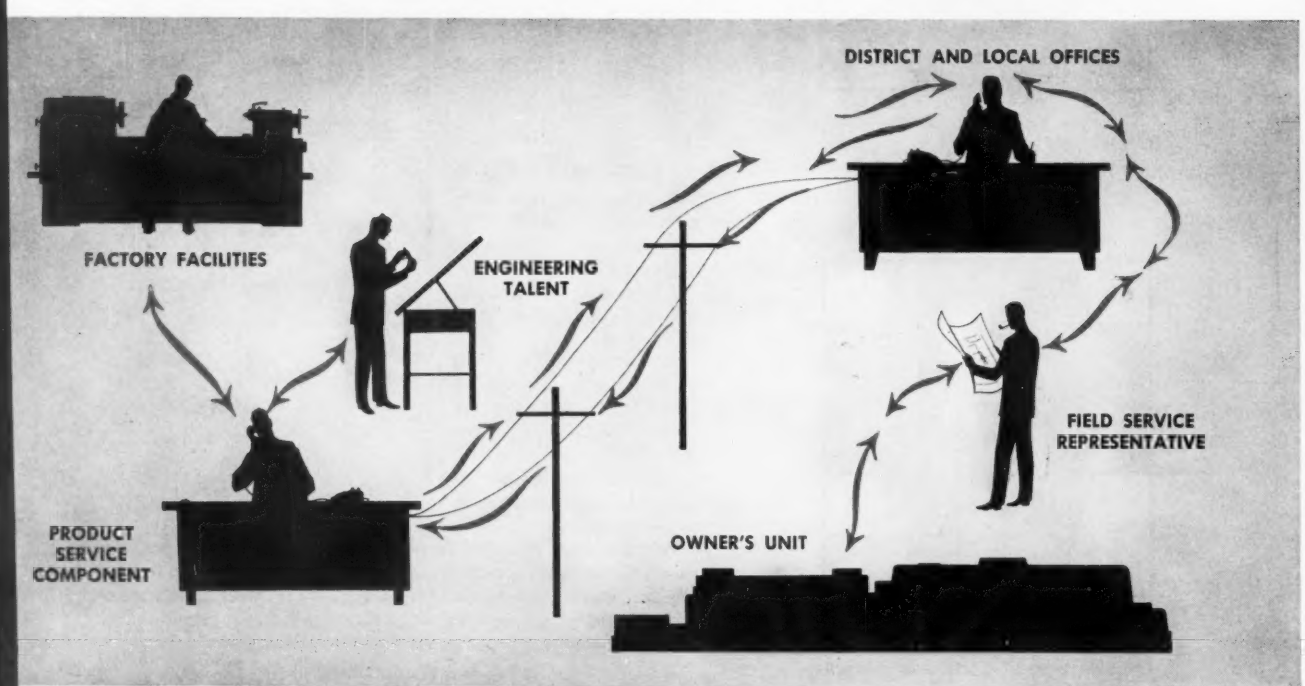
LARGER UNIT SIZES and improved heat rates have helped utilities reduce operating labor and maintenance costs. However, if these costs are projected at the 1947–57 inflationary rate, this trend will be reversed as indicated above. Accordingly, General Electric is constantly strengthening all phases of its present intensive efforts that help in *KEEPING POWER MAKERS ON THE LINE*, thereby promoting even more economical generation of electricity.



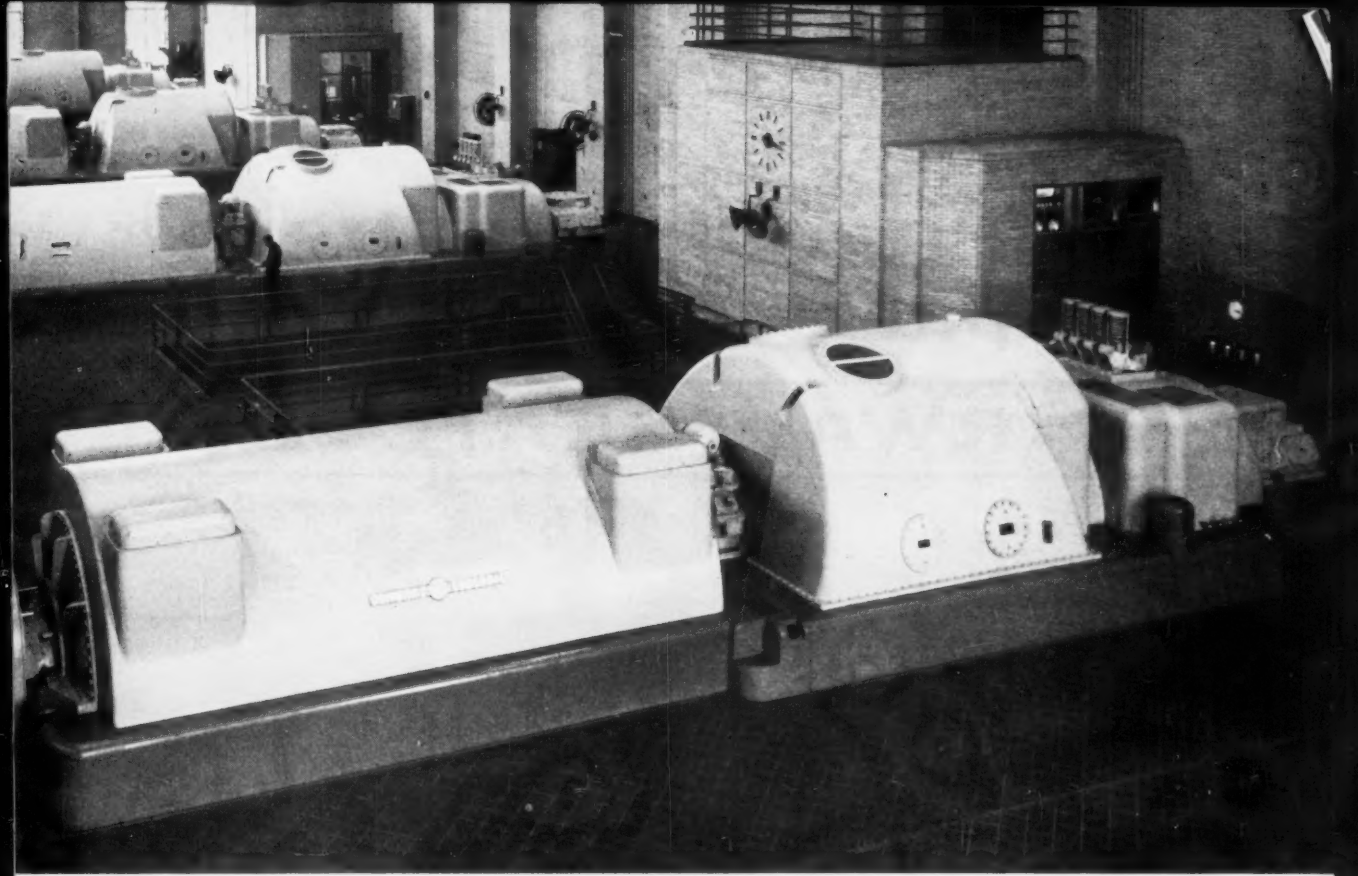
KEEPING POWER MAKERS ON THE LINE, operating at top efficiency is the job of over 400 G-E turbine-generator field representatives backed by well-rounded district organizations, and by complete manufacturing facilities and engineering talent at the factory. Pictured here are four General Electric units installed at the Albany Steam Station, Niagara Mohawk Power Corporation.



Completely integrated service helps keep



TWO-WAY FLOW OF SERVICE INFORMATION through the Product Service component enables factory "know-how" to supplement the efforts of your field service representatives, and permits design and manufacturing specialists to take full advantage of field operating experiences.



General Electric power makers on the line

From the time an order is placed, through design, manufacturing, installation, and during the life of every unit, a well-trained service team is constantly available. Turbine-generator field representatives and local specialists are backed by a Product Service organization at the factory. This component channels all incoming and outgoing information and coordinates the application of factory talents and facilities to individual owner's problems.

Here are some ways General Electric service helps maintain the product superiority built into each unit:

Installation Service Study Team—*helps simplify field erection by continually studying methods for reducing installation time and cost. It also seeks easier inspection procedures by suggesting appropriate improvements in equipment design.*

Performance Interpretation—*helps owners evaluate abnormal sectional pressures and efficiencies, loss of capacity, and other operating irregularities. General Electric initiates tests to prove new designs, and aids owners in conducting their own performance tests on duplicate machines.*

Engineering Consultation—*is continuously available from factory components. Here electrical and mechanical engineers specialize in providing prompt supporting attention to problems that may arise during the life of your unit.*

Materials and Processes Laboratory Assistance—*is offered for any unusual service requirement. Nearly 300 physicists, chemists, specialists and technicians are available for field studies, consultation, and advanced non-destructive testing.*

Maintenance Task Force—*establishes procedures to speed repairs and minimize outages by: assuring efficient repair routines, carefully analyzing shop operations to eliminate uncertainties, and coordinating our action with owner's requirements.*

Material Procurement Advantages—*help reduce maintenance downtime. Large volume production, a backlog of currently approved materials such as composite forgings, tubing, and bar stock, and an efficient purchasing organization constitute powerful aids in meeting emergency requirements.*

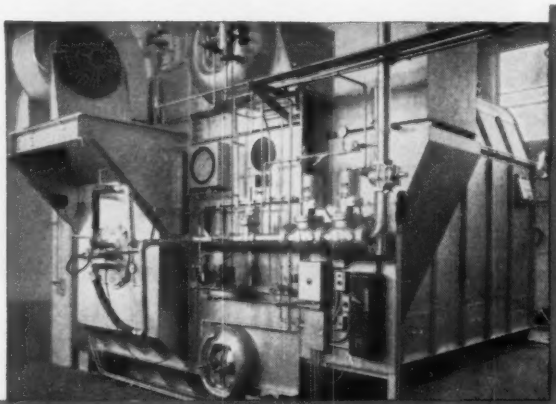
Complete service—designed to provide maximum assistance and satisfaction to the owner—is part of the "added value" you purchase with every General Electric steam turbine-generator. For more information, write for publication GED-3666, Large Steam Turbine-Generator Department, Schenectady 5, New York. 254-76

Progress Is Our Most Important Product

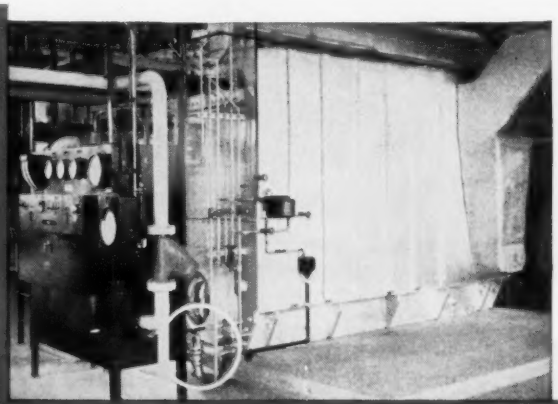
GENERAL ELECTRIC

the blow-off valve trend on "package" boilers is

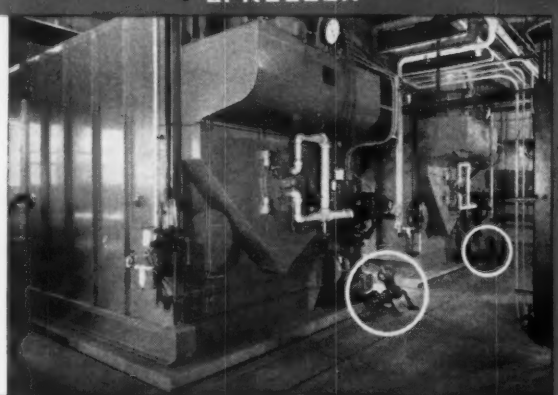
YARWAY SEATLESS



● E. KEELER



● COMBUSTION ENGINEERING



● TITUSVILLE

● KEWANEE-SPRINGFIELD

SEE YARWAY EXHIBIT AT
THE NEW YORK POWER SHOW
BOOTH 532

YARWAY BLOW-OFF

■ More and more leading manufacturers of package-type boilers are featuring Yarway Blow-Off Valves on their units. Many are standardizing on Yarways.

The reason—good blow-off valves help good package boilers *perform better*.

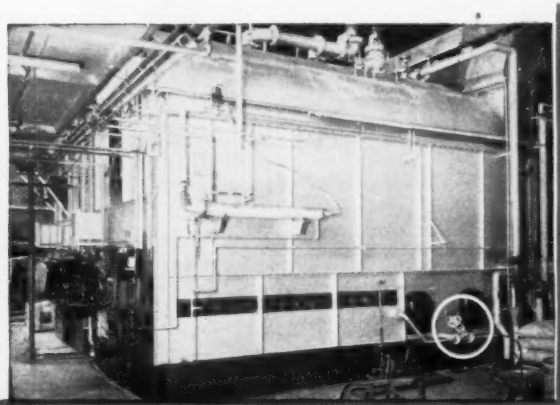
Yarway—known for nearly 50 years for *quality* blow-off valves—offers advanced design, dependable service, and reasonable cost . . . three features attractive to all boiler users.

The Yarway Seatless Blow-Off Valve, with balanced hollow sliding plunger and no seat to score, wear, clog or leak, is the most widely used valve for low and medium pressures.

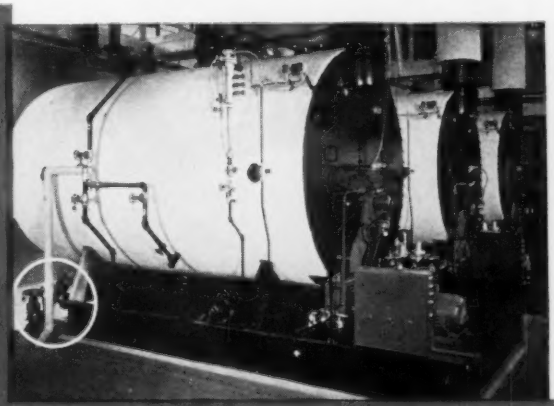
Specify Yarway Seatless Blow-Off Valves on your package boilers. All boiler makers will supply them.

For full description of Yarway Seatless Blow-Off Valves write for Yarway Bulletin B-426.

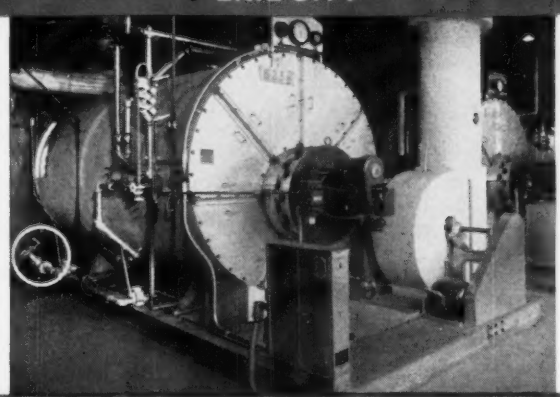
YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES



● ERIE CITY



● CLEAVER-BROOKS



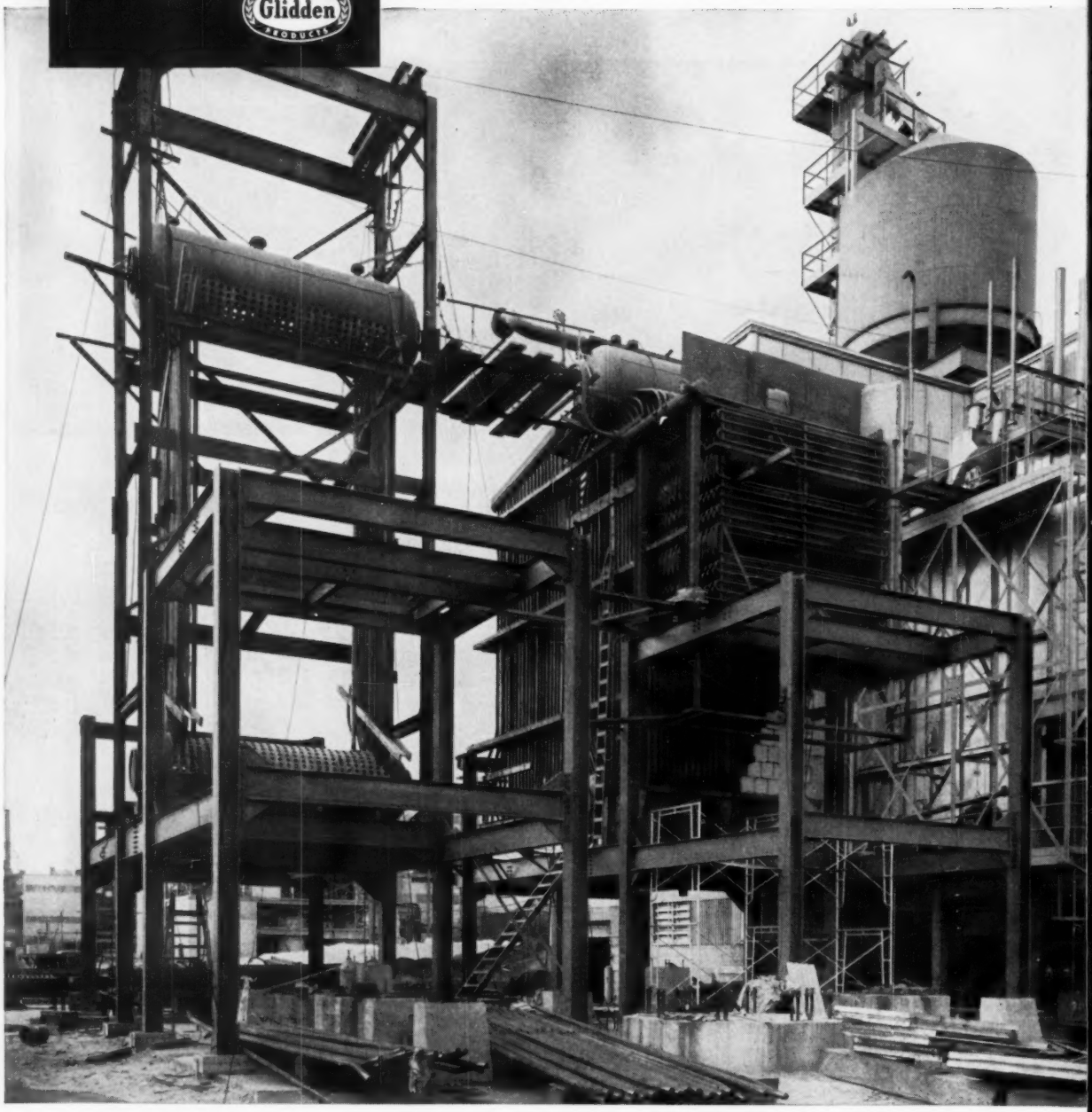
● PREFERRED UTILITIES

● **Yarway Seatless Tandem Blow-Off Valve** (angle-straightway combination) with angle valve sectioned to show balanced sliding plunger design.

● **Yarway Seatless Tandem Blow-Off Valve,** angle-angle combination, straightway-angle or straightway-straightway tandems also available.

VALVES

Power for producing Republic



Glidden pigments starts with ELECTRUNITE Boiler Tubing

Keeping pigment production up is a big job that demands power plant dependability. And dependable power starts with Republic ELECTRUNITE® Boiler Tubing at the new Ardian Joyce Works of the Chemicals-Pigments-Metals Division, The Glidden Company, Baltimore, Maryland.

Power for this pigment production comes from units of 70,000 pounds per hour with 725 p.s.i. saturation temperature. These units were designed, constructed, and installed by Riley Stoker Corporation. Republic ELECTRUNITE was used throughout for the boiler waterwalls and the economizer.

Republic Tubing was installed with the assurance of built-in quality. ELECTRUNITE is made of highest quality flat-rolled open-hearth steel produced in Republic's own mills to Republic's rigid specifications.

Each length of Republic ELECTRUNITE Boiler Tubing is hydrostatically or electronically tested to conform with the applicable ASTM specifications and the ASME Boiler and Pressure Vessel Code, as well as local, state, and boiler insurance requirements. Stress values for Republic ELECTRUNITE tubes are the same as those for tubes made by other processes for temperatures up to 850°F mean tube temperature. Various sizes and wall thicknesses of ELECTRUNITE are available for pressures over 2000 p.s.i.

For dependable boiler, condenser, heat exchanger operation, specify Republic ELECTRUNITE. For additional facts call your Republic representative or send the coupon below.

QUALITY YOU CAN MEASURE—FARROWTEST®! Not a laboratory theory, not a mere inspection tool, but an exclusive production test that detects and rejects defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with table below, at no extra cost.

FARROWTEST REJECT TABLE

Wall Thickness	Minor Dimension of the Defect (Length or Depth)	Length X Depth Area in Square Inches
20 ga.	.006″	.0025″
18 ga.	.006″	.003″
16 ga.	12½% of Wall	.003″
14 and 13 ga.	12½% of Wall	.004″
12 ga. and heavier	12½% of Wall	.005″

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

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Please send additional facts and literature:

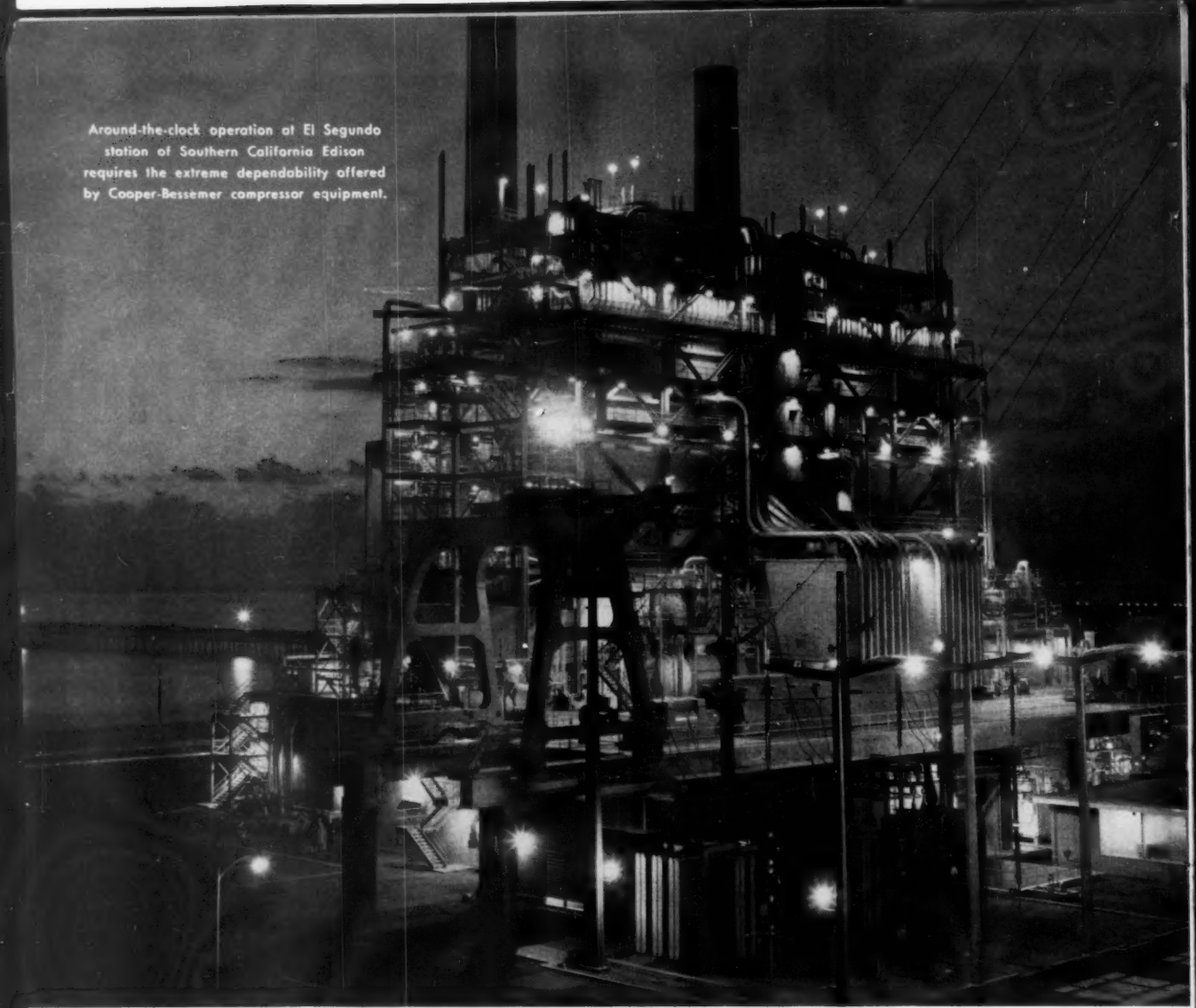
☐ ELECTRUNITE Boiler Tubes
☐ ELECTRUNITE Heat Exchanger Tubing
☐ Carbon ☐ Stainless ☐ FARROWTEST Brochure

Name_____ Title_____

Firm_____

Address_____

City_____ Zone___ State_____



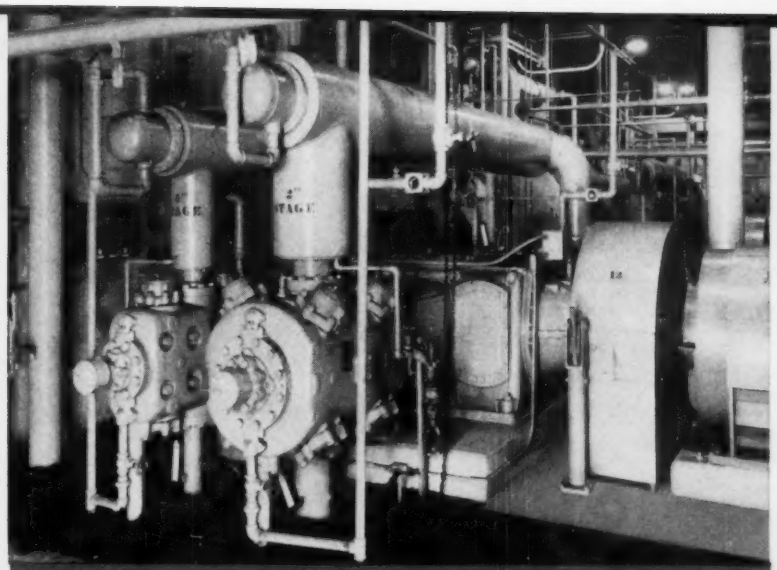
Around-the-clock operation at El Segundo station of Southern California Edison requires the extreme dependability offered by Cooper-Bessemer compressor equipment.

Increase boiler capacity,

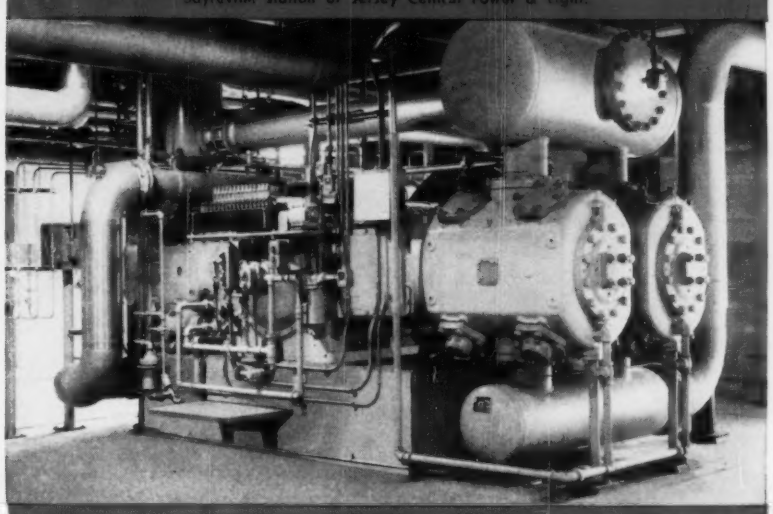
...with Cooper-Bessemer air Compressors for soot blowing service

Steam stations everywhere profit from multi-stage Cooper-Bessemer M-Line air compressors used to clean slag and ash deposits from boiler unit surfaces. For example, four steam stations of Southern California Edison Company, the Sayreville station of Jersey Central Power & Light Company, the Breed Plant No. 1 of Indiana and Michigan Electric Company, and the Philip Sporn Plant Unit No. 5 of the Ohio Power Company . . . *all* depend on the experience and efficiency offered by Cooper-Bessemer.

You'll find air cleaning with Cooper-Bessemer equipment the most effective and economical answer to a continuing problem. Automatic regulation, heavy-duty con-

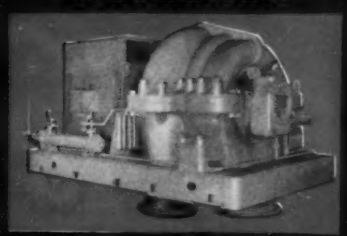


Extreme accessibility is another plus feature of motor-driven PM compressors in the Sayreville station of Jersey Central Power & Light.

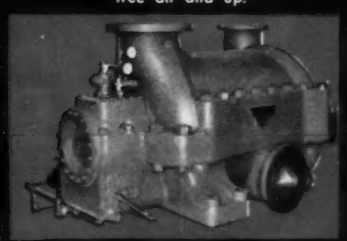


This compact Cooper-Bessemer PM compressor, rated 500 hp at 400 rpm, cuts trouble and costs at the El Segundo steam-electric generating station.

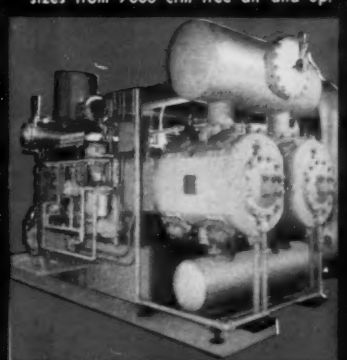
TO MEET SEVERE SERVICE REQUIREMENTS



Direct motor-driven multi-stage centrifugal compressors for sizes from 3000 cfm free air and up.



Multi-stage centrifugal compressors for sizes from 7000 cfm free air and up.



Multi-stage reciprocating compressors for up to 30,000 cfm free air.

availability and efficiency

struction and a range of horsepower sizes offer you the ideal unit.

For your next steam generating unit, check with Cooper-Bessemer for the latest in soot blowing services. Sizes are available up to 10,000 hp in both reciprocating and centrifugal designs. Write for additional information.

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ENGINE OR MOTOR DRIVEN

Cochrane

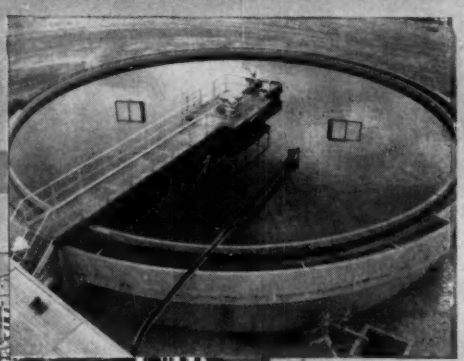
. . . pioneers in water

The history of many major developments in boiler feedwater treatment is a history of Cochrane firsts.

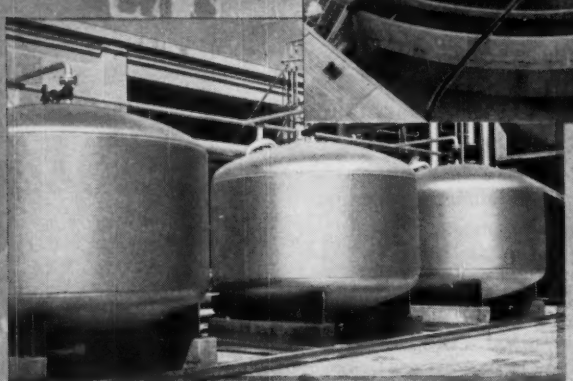
This broad background and experience, dating back to 1863, enables Cochrane to present impartial recommendations for the best process and equipment design to meet any set of water conditions.

COCHRANE MILESTONES IN THE HISTORY OF WATER CONDITIONING

1885—Commercial introduction of the open or direct contact feedwater heater.
1900—Commercial application of heat as an aid in water softening.
1907—Development of Cochrane Multiport Valve for over pressure relief and control.
1910—Vertical sedimentation tank with conical uptake funnel and conical bottom to improve efficiency of sedimentation.
1912—Use of metering feedwater heaters.
1912—Use of lime in hot process treatment.
1916—Cochrane differential pressure type chemical proportioner for accurate and dependable continuous feeding of chemicals in direct proportion to raw water flow.
1920—Use of vacuum breakers on hot process softener sedimentation tanks.
1921—Development of tubular counterflow deaerating heater to improve degasification of boiler feedwater.
1921—Development of the use of non-siliceous filtering materials for hot process softeners.
1923—Backwashing of filters with hot softened water from sedimentation tank with recovery of hot backwash water.
1924—Development of cross-flow tray type deaerator.
1925—Use of jet heaters with hot process water softeners.
1928—Use of supplementary phosphate treatment to maintain steam evaporating surfaces in high pressure boilers.
1929—Commercial application of Cochrane parallel downflow deaerator.
1929—Development of atomizing deaerator.
1931—Introduction of primary phosphate type treatment in hot process softeners.
1933—Deaeration by atomization in hot process softeners.
1934—Jet-tray type deaerator with direct contact vent concentrating preheater.
1935—Deaerating hot process softeners developed for large capacities.
1938—Electrically operated chemical proportioners.
1939—Use of recirculated sludge in hot process softeners.
1939—Application of hot process softeners for silica reduction.
1940—Use of phosphoric acid in hot process softener as primary softening reagent.
1943—Commercial application of cold water vacuum deaerators.
1947—Development of Cochrane Hydromatic single control valve.
1947—Development of direct contact vent condenser for deaerators.
1948—Gas concentrating direct contact jet heater for hot process softeners.
1948—Commercial application of demineralization for silica removal.
1949—Hot process two-stage softener, lime treatment followed by zeolite.
1950—Hot zeolite softeners backwashed with filtered water with backwash return to filter inlet header to prevent overloading of sedimentation tank during zeolite backwash operation.
1950—Commercial application of salt-splitting anion chloride exchange process for dealkalizing.
1951—Anti-flash rinse control for hot zeolite systems.
1952—Automatic hot zeolite softeners.
1953—Introduction of rubber-lined Hydromatic single control valve for use with demineralizers and acid regenerated ion exchangers.
1954—Flow compensating, single compartment backwash arrangement for hot process softeners.
1954—Introduction of salt-splitting anion hydroxide exchange process for silica removal without demineralizing.
1955—Development of caustic brine method of restoring anion resin to remove fouling organic agents.
1955—First large automatic flat bottom mixed bed scavenger demineralizers to treat condensate.
1956—First double deck weak and strong base anion resin beds in single units.
1957—Multi-bed demineralizer to follow hot lime zeolite using single double deck cation-anion units.
1957—Multi-bed demineralizer units without anthracite supporting beds.
1958—High rate mixed bed demineralizer development.



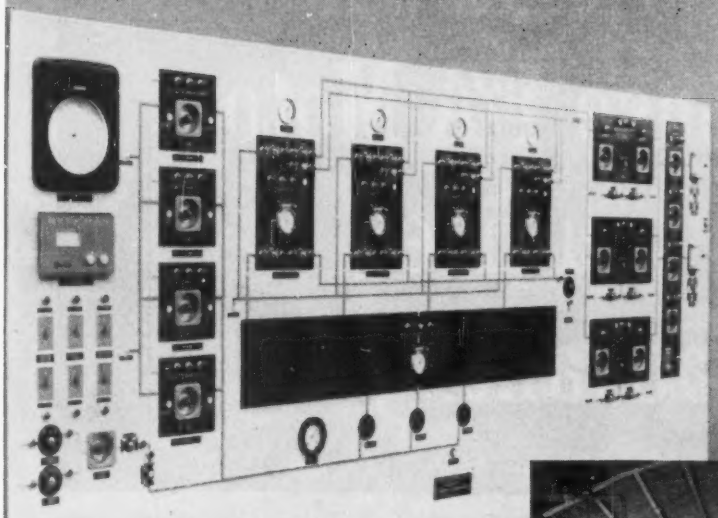
Cochrane Solids Contact Reactor, 72' diameter for oil flooding operation.



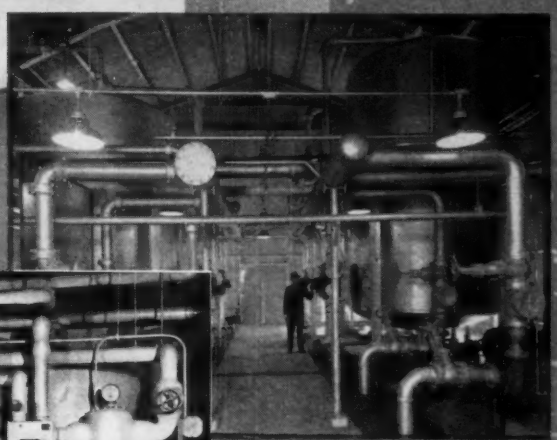
100,000 gph Cochrane Sludge Blanket Hot Process Softener at a steel company.

Cochrane Filters on hot process softener installation.

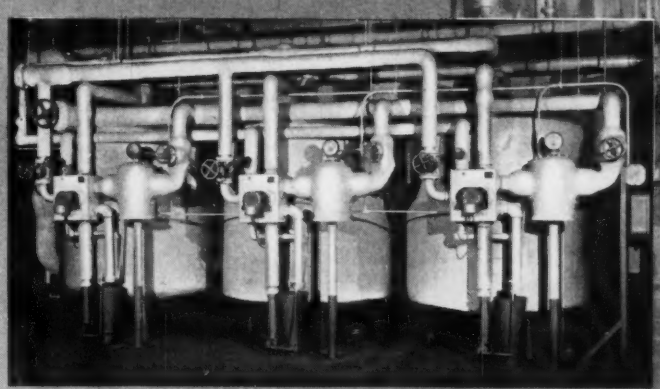
conditioning.



Typical Cochrane Panel Board for controlling automatic water conditioning system.



Cochrane Hydromatic Single Control Valve automatically controls this Cochrane Demineralizer in a large oil refinery.



Cochrane Automatic Zeolite Softener. Capacity 230,000 lbs./hr.

50,000 gpm Cochrane Hot Lime Zeolite System for a refinery.

COCHRANE CORPORATION WATER AND HEAT ENGINEERS SINCE 1863 PHILADELPHIA

Water Conditioning

Demineralizers • Hot Process Softeners • Hot Lime Zeolite Softeners • Zeolite Softeners • Solids Contact Reactors Dealkalizers • Pressure and Gravity Filters • Hydromatic Single Control Valves for Ion Exchange Equipment

Deaeration

Tray Type Deaerators • Atomizing Deaerators • Jet-Tray Deaerators • Cold Water Deaerators • Surface Type Deaerating Hot Water Heaters

Steam Specialties

Continuous Blowoff Systems • Steam Purifiers • Oil Separators • Multiport Relief Valves • Multiport Drainers • Dischargers • Receiver Separators • Exhaust Heads • C-B Condensate Return Systems

Cochrane

CORPORATION

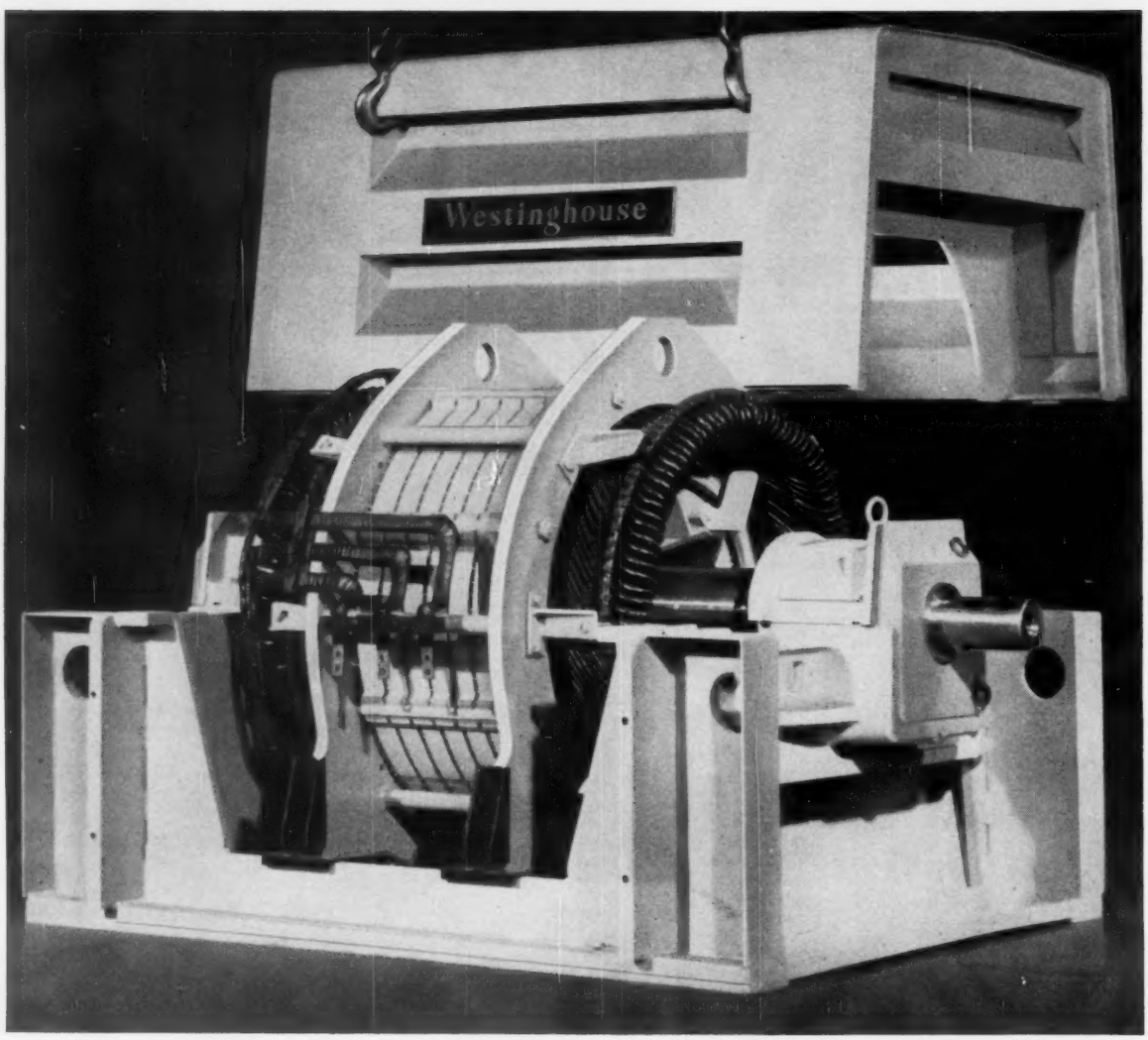
3106 N. 17TH STREET, PHILADELPHIA 32, PENNA.

NEW YORK • PHILADELPHIA • CHICAGO

Cochrane Water Conditioning Ltd., Toronto 4, Montreal 1, Winnipeg 1, Canada—Representatives in 30 principal cities in U.S.; Paris, France; La Spezia, Italy; Mexico City, Mexico; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Santiago, Chile; Honolulu, Hawaii; Manila, Philippine Islands.

Pottstown Metal Prods. Div.—Custom built carbon steel and alloy products.

Revolutionary new Westinghouse F/A Motor gives you five major advantages



First fully accessible motor ... takes guesswork out of inspection

For the first time in large motor history, the motor housing is completely separate from the stator, with all the benefits such construction implies.

Inspection — once a matter of partial visibility and guesswork — is now a thorough and easy operation which insures your motor investment. Advantages impossible in conventional motors are standard features of this F/A Motor design.

1. Full accessibility. Total inspection is possible for the first time. Enclosures are quickly removed, easily replaced. Reassembly is automatically precise.
2. Inherently quiet. Housing is isolated from the stator, reducing transmission of vibration and noise.
3. Thermalastic® insulation. Recognized as the finest available, it assures long life and protection of coils.
4. The same basic components — rotor, stator, bearings — which have made Westinghouse motors famous for long, efficient service life.
5. Easy to connect. No conduit box. Cables pass through the base bottom with extra-ample room to connect motor leads.

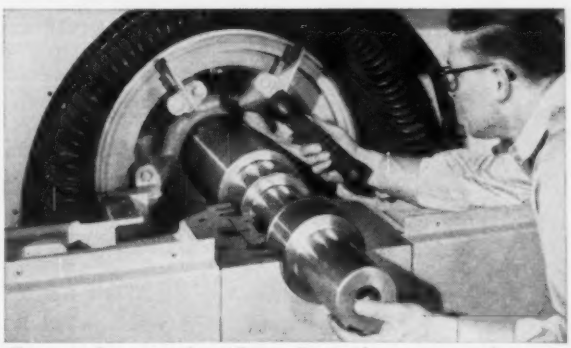
These and many other qualities make the new Westinghouse F/A Motor your best investment. It is presently available in large induction motors, both squirrel-cage and wound rotor. Various types of enclosures include dripproof, splashproof, weather protected, force ventilated, enclosed self-ventilated with cooler and TEFC tube type. Horsepower ratings range from 250 up to 7000, depending on speed.

For full information, call your Westinghouse representative, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

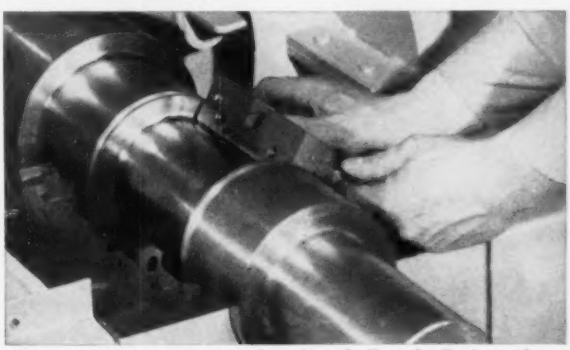
J-15011

YOU CAN BE SURE...IF IT'S Westinghouse

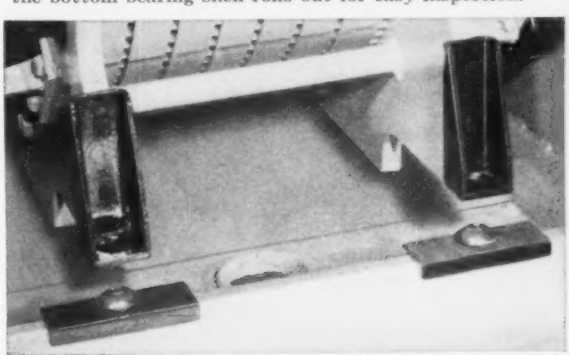
Protruding conduit boxes are gone. Cable comes up through the base, leaving plenty of room for connecting motor leads.



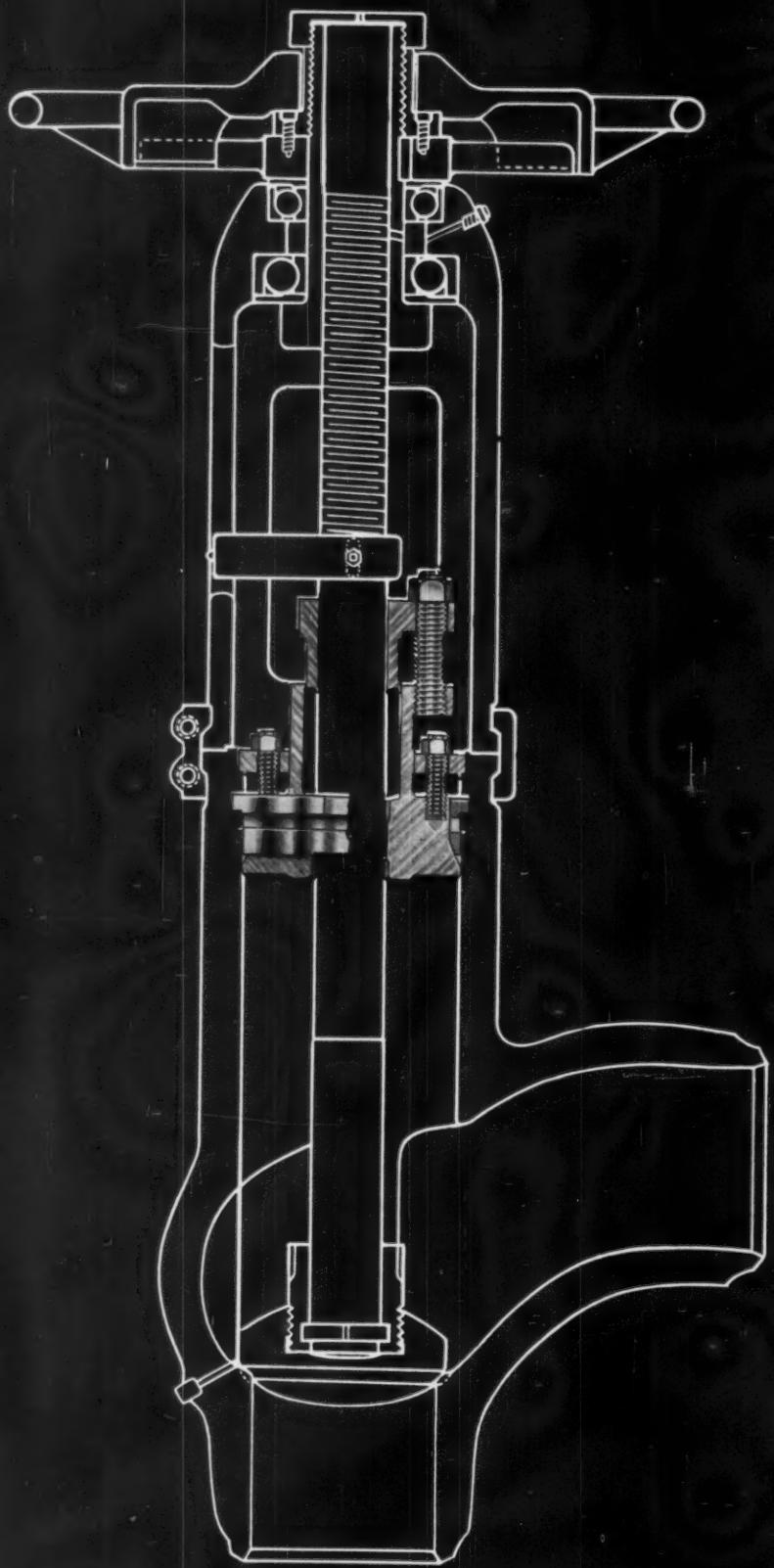
By merely removing the end panels, you can inspect windings and bearings.



Remove bearing cap, top bearing shell and oil ring; then the bottom bearing shell rolls out for easy inspection.



Special ball and socket type locator joints simplify removal and replacement of stator. In reassembly, perfect realignment is automatic.



EDWARD PRESSURE-SEAL ANGLE VALVE

What's New from Edward Valves

New Products . . . Problems and Solutions. . . Information on Steel Valves from Edward, Long-Time Leader in the Field!

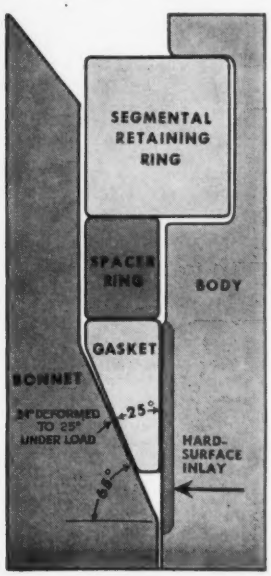
Not A Single Failure Reported In 5 Years

on unique "Pressure-Seal" body-bonnet joint!*

Advances in service temperatures (above 800 F) led to introduction, in 1945, of commercial steel valves with pressure-seal bonnet joint construction. These superseded bolted joint valves of earlier design.

The original 45° pressure-seal gasket, used by Edward and other manufacturers, was a significant improvement in minimizing leakage. But scientists in the Edward Research Laboratories refused to accept this as the best that could be done, set out to develop a better pressure seal joint.

In 1953 Edward research paid off: a completely new Edward pressure-seal design—with 25°–65° joint—was introduced. Design is shown in diagram on this page. The change in gasket angle, plus other Edward improvements described here, brought an end to bonnet joint leakage in pressure-seal valves.



Literally thousands of Edward pressure-seal valves have been installed since 1953 in a great variety of services. Of these, *not a single case of failure has ever been reported.*

Here's Why Edward Improved "Pressure-Seal" Succeeded:

SEALING AREA MULTIPLIED!
Improved gasket design *triples* sealing surface area, virtually eliminates possibility of leakage.

SEALING FORCE DOUBLED!
Angular relationship of bonnet, gasket and body directs more line load *outward* against the gasket, doubles sealing force.

SPECIAL GASKET SEAL-COATING!
A special corrosion-resistant malleable coating (.001 inch thick) is applied to gasket, flows into minute irregularities, assures perfect seal.

IMPROVED BODY SEALING SURFACE!
Possibility of any microscopic casting porosity in vital body-gasket sealing zone is avoided by inlay of corrosion resistant hard-surfacing material.

EASY DISASSEMBLY!
Body bore has been enlarged just above gasket area; this permits gasket to be easily lifted out, after segmental retaining ring and spacer are removed.

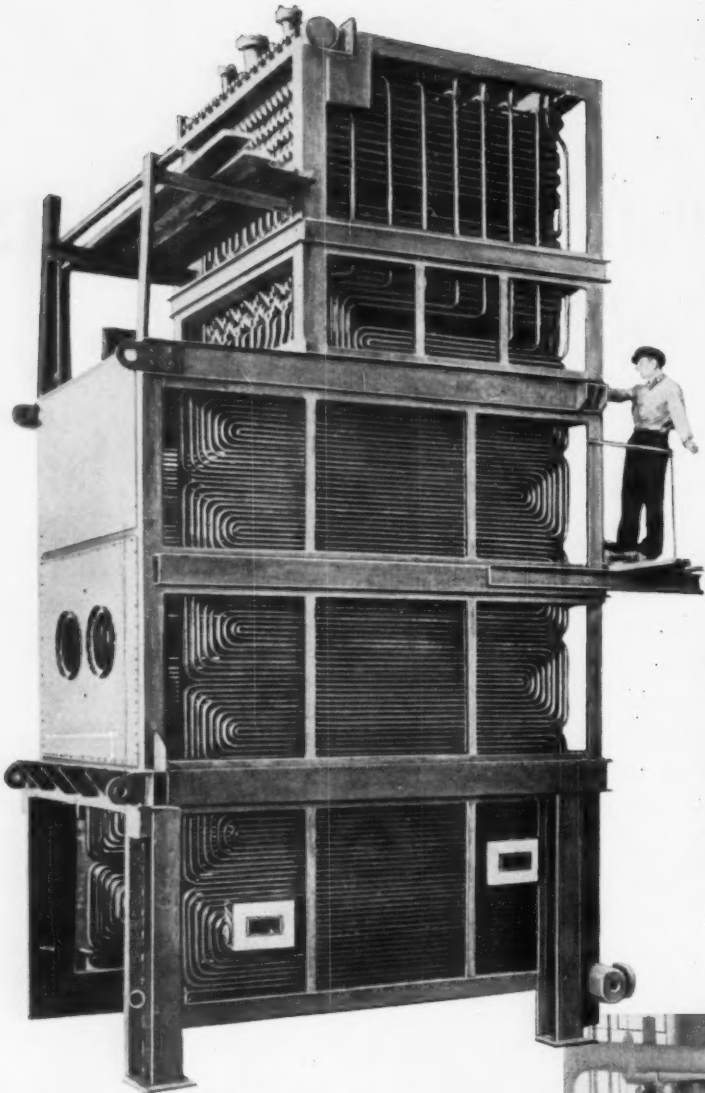
GASKET DAMAGE ELIMINATED!
Sharp edge of gasket has been rounded-off, eliminates possible damage to gasket during handling or storage.

EDWARD VALVES, INC.
1230 West 145th Street, East Chicago, Indiana
Subsidiary of
ROCKWELL MANUFACTURING COMPANY

Represented in Canada by
LYTLE ENGINEERING SPECIALTIES, LTD., 360 Notre Dame St. W., Montreal 1, Que.

Edward builds a complete line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, gage and special designs; for pressures up to 10,000 lbs; with pressure-seal, bolted, union or welded bonnets; with screwed, welding or flanged ends.

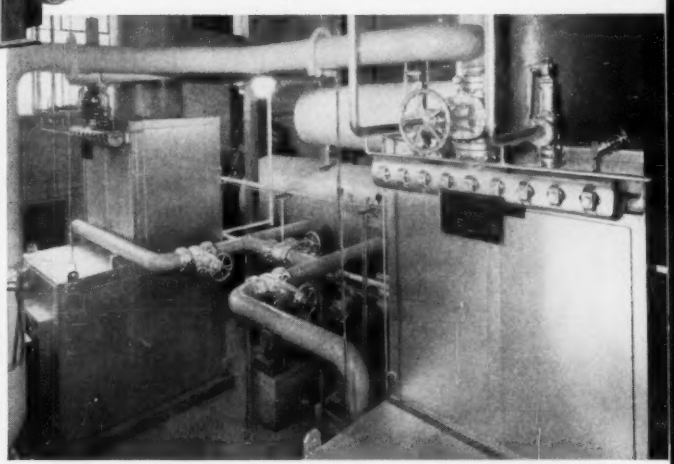
*T. M. Reg. U. S. Pat Off.



Shop assembly view showing steel frame and pressure parts for 25-million Btu unit prior to installation of refractory, insulation block, and welded gastight casing.

In new plants large and small...

The C-E high temperature water boiler offers savings of 10 to 20%



Compactness of C-E HCC Boilers is demonstrated in this view of two 10-million Btu units installed at a new Michigan high school.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

C-190

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT, PULVERIZERS, FLASH DRYING SYSTEMS, PRESSURE VESSELS, SOIL PIPE

The list at right points up the versatility and widespread acceptance of Combustion Engineering's HCC boiler. For industrials, schools, institutional use, military bases—wherever there is extensive space to be heated—C-E high temperature water has a place.

Featuring the same principle applied by Combustion in many of its large utility boilers, the C-E LaMont Controlled Circulation Hot Water Boiler offers a compact and effective arrangement of heating surfaces. This design gives precision temperature control, and, dependent upon local conditions, the HCC can save 10 to 20 per cent in maintenance and operating costs—a significant factor when considering a heat source.

Available in a wide capacity range—from 10 to 300-million Btu's—these boilers operate at water pressures up to 500 psi and temperatures to 470 F or higher. The smaller capacity HCC's are completely shop-assembled, while the intermediate and large units are shipped in varying stages of assembly. This C-E practice greatly reduces erection costs.

If you are in the market for boilers, either for space heating or process requirements, it may prove greatly to your advantage to investigate C-E high temperature water as your heat source.

Because individual needs vary, *both* steam and hot water have their applications. Combustion Engineering can furnish either, and our engineers are exceptionally qualified to discuss *impartially* with you or your consultants the method most suitable for your situation.

Write for further details on Combustion Engineering's High Temperature Water Boilers.

Representative list of C-E HCC Boilers in service, under construction, or on order

	No. of Units	Normal Output ea.—Btu/Hr. (millions)	How Fired
A. E. Smith High School Riverview, Michigan	2	10	Oil
J. Bishop & Co. Malvern, Pa.	1	12	Oil
Colorado State College Greeley, Colo.	1	60	Oil— Nat. Gas
Cross Company, The Frazer, Michigan	2	12	Nat. Gas— Oil—
Defense Construction Ltd. Camp Gagetown, N. B., Canada	3	70	Pulv.Coal— Gas
Erie Mining Company Aurora, Minn.	2	65	Stokers— Oil or Gas
Convair Astronautics Div. General Dynamics Corp. San Diego, Calif.	2	30	Oil— Nat. Gas
General Motors Overseas Santos, Brazil	1	12	Oil
Hillcrest Medical Center Tulsa, Oklahoma	1	30	Nat. Gas
Marquardt Aircraft Co. Ogden, Utah	2	12	Oil— Nat. Gas
Michigan State University Oakland, Michigan	1	12	Oil— Nat. Gas
New Florida State Prison Raiford, Florida	2	30	Oil— Nat. Gas
North Carolina Wesleyan College Rocky Mount, N. C.	2	18	Oil— Nat. Gas
U. S. Air Force Academy Colorado Springs, Colorado	3 2	100 30	Oil— Nat. Gas
U. S. AIR FORCE: Dayton Air Force Base Dayton, Ohio	1	30	Stoker
Dover Air Force Base Dover, Delaware	3	50	Oil— (Fut. Coal)
Forbes Air Force Base Topeka, Kansas	3	42	Oil— Nat. Gas (Fut. Coal)
Grand Forks Air Force Base Grand Forks, North Dakota	2	25	Stokers— Oil
Minot Air Force Base Minot, North Dakota	2	25	Stokers— Oil
Plattsburgh Air Force Base Plattsburgh, N. Y.	2	50	Oil
Portsmouth Air Force Base Portsmouth, N. H.	2	110	Oil— Nat. Gas (Fut. Coal)
Wilmington Air Force Base Wilmington, Ohio	1	16	Stoker
Wrightstown Air Force Base Wrightstown, N. J.	4	50	Stokers
Wuthsmith Air Force Base Osceda, Michigan	2	25	Stokers
Air Force Base Torejon, Spain	3	43	Oil
U. S. Navy Auxiliary Air Station Fallon, Nevada	2	15	Oil

One of the many large plants using C-E High Temperature Water Boilers is Convair-Astronautics Division of the General Dynamics Corporation. Installed at this new $40-million center for Atlas Intercontinental Ballistic Missile research, development, manufacture, and primary testing are two 30-million Btu HCC Boilers.

It will pay you to investigate

INFILCO Hot Process Lime-Soda Softeners

for boiler feedwater treatment

INFILCO'S ADVANCED EQUIPMENT design for this familiar process provides superior treatment for intermediate pressure boilers, usually at lower overall cost than ion exchange.

No other *single* process gives you *all* these advantages:

1. Clarification
2. Softening
3. Solids Reduction
4. Alkalinity Reduction
5. Silica Reduction
6. Feedwater Heating
7. Deaeration
8. Continuous operation with inexpensive, safe chemicals

In equipment, as in results, INFILCO offers the quality you need... your choice of two custom-engineered designs:

1. ACCELATOR® HOT-FLOW® Softener. Internal recirculation by steam lift, independent of throughput rate, is an exclusive feature of this equipment and assures optimum solids contact for chemical efficiency at high and variable flow rates. Provides integral multi-pass deaeration by concurrent scrubbing action of steam.

2. "HOT-FLOW" Softener, slurry retention type Refinement of traditional method provides extended contact with reactive solids, clarifies treated water by upflow through suspended slurry pool. Especially applicable to low and reasonably constant flow rates. Separate INFILCO recirculating type deaerating heater assures lowest oxygen residual.

Complete systems by INFILCO may also include Condensate Deaerating Heaters, "INFILCARB" Filters, and CATEXER® Hot Zeolite Softeners.

Let the INFILCO engineer in your vicinity tell you more about this interesting equipment. Or write today for additional information and your copy of Bulletin 1855.

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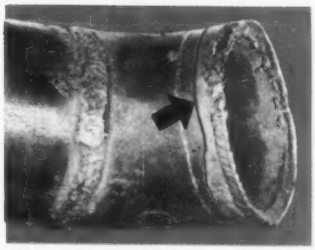
INFILCO

EMINENCE IN ENGINEERING DESIGN OF WATER, SEWAGE & WASTE TREATING EQUIPMENT... SINCE 1894

Watch out for the risks of

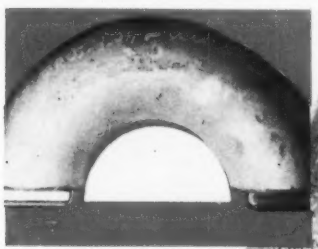
QUESTION MARK FITTINGS!

- *WASTED DOLLARS*
- *PRODUCTION SHUTDOWNS*
- *HAZARDS TO LIFE*
- *DAMAGE TO YOUR REPUTATION*



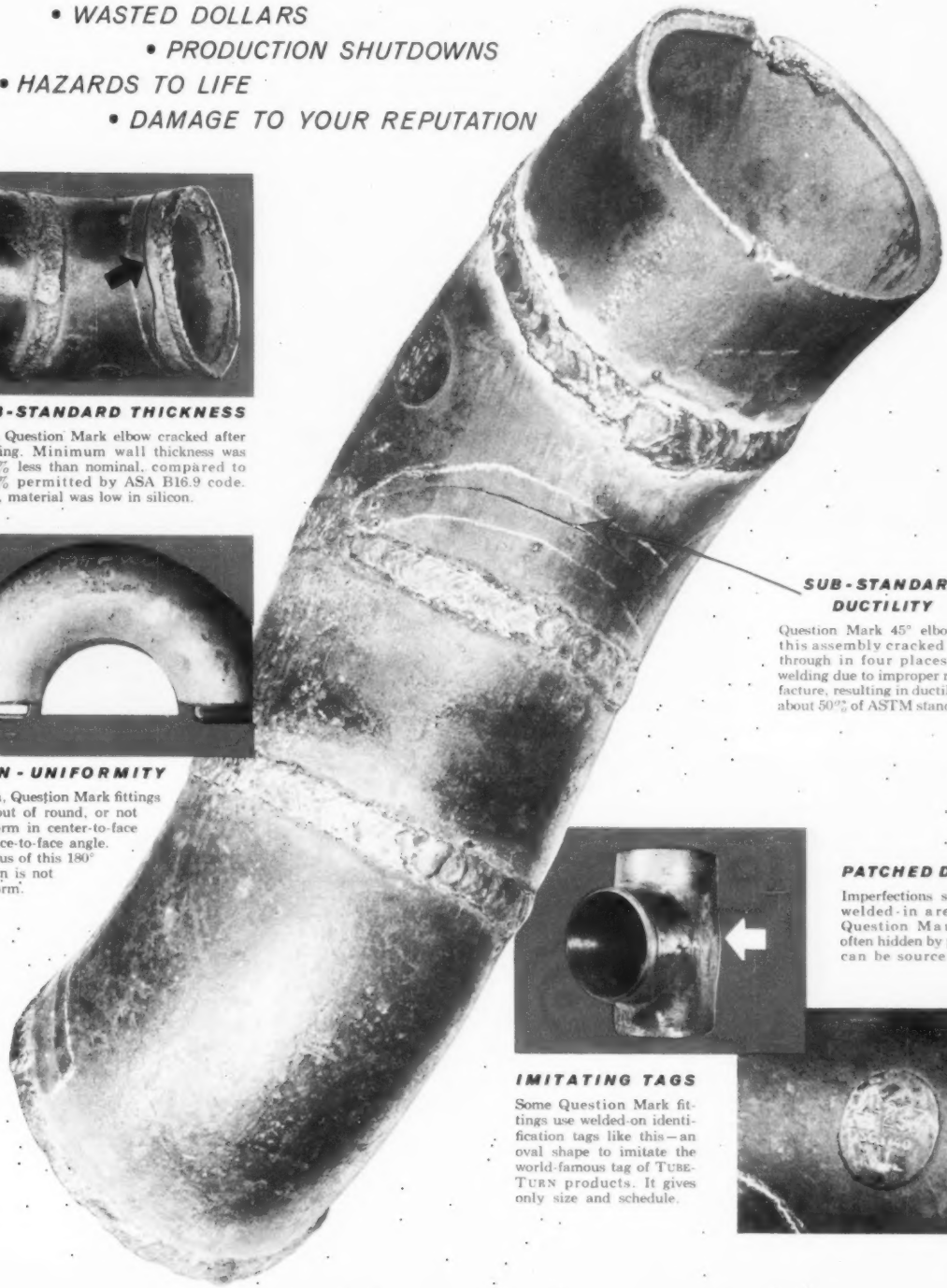
SUB-STANDARD THICKNESS

This Question Mark elbow cracked after welding. Minimum wall thickness was 24.9% less than nominal, compared to 12.5% permitted by ASA B16.9 code. Also, material was low in silicon.



NON-UNIFORMITY

Often, Question Mark fittings are out of round, or not uniform in center-to-face or face-to-face angle. Radius of this 180° return is not uniform.



SUB-STANDARD DUCTILITY

Question Mark 45° elbows of this assembly cracked clear through in four places after welding due to improper manufacture, resulting in ductility of about 50% of ASTM standards.

PATCHED DEFECTS

Imperfections such as the welded-in area of this Question Mark tee are often hidden by paint. They can be source of failure.

IMITATING TAGS

Some Question Mark fittings use welded-on identification tags like this—an oval shape to imitate the world-famous tag of TUBE-TURN products. It gives only size and schedule.

A message in the interests of top-quality piping . . . by Tube Turns, Louisville, Kentucky

TO AVOID THESE RISKS . . .

TUBE-TURN *Welding Fittings are completely identified. Information given: Manufacturer's identification, size and wall thickness, material or type number, schedule number or weight, laboratory control number.*

specify and buy top-quality

TUBE-TURN® PRODUCTS

AVAILABLE NEARBY. Your Tube Turns' Distributor gives you prompt delivery from a complete line of more than 12,000 stocked items of TUBE-TURN products. Photo courtesy Central Rubber & Supply Co., Inc., Indianapolis.

"Cheap" Question Mark fittings can be mighty costly in the long run. It pays to safeguard your piping investment, *and your reputation*, by insisting on *known* fittings.

When you specify and buy TUBE-TURN* Fittings and Flanges, you know you are getting unsurpassed quality. They meet all American Standard and Safety Code requirements and are fully and permanently identified for your protection.

The trademarks "TUBE-TURN" and "tt" are applicable only to the quality products of Tube Turns.

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

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DIVISION OF CHEMETRON CORPORATION

Louisville 1, Kentucky

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Kansas City • Los Angeles • Midland • New Orleans • New York • Philadelphia
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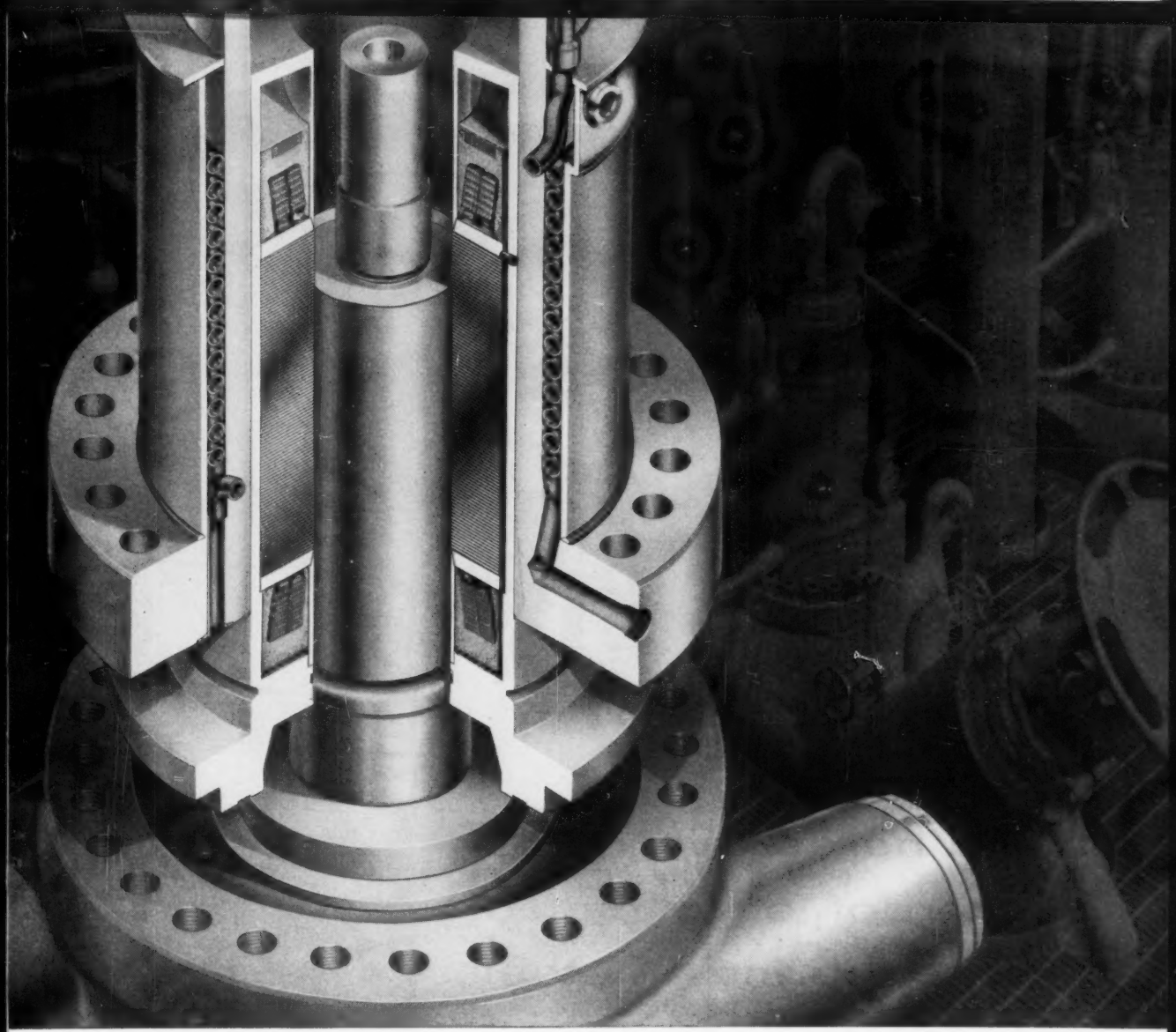
DISTRICT OFFICES: Edmonton • Montreal • Toronto • Vancouver

CHEMETRON



New Removable Stator Design, "Canned" Motor-Pump (exploded cutaway view)

For better boiler circulation...specify Westinghouse "canned" motor-pumps

Controlled circulation boilers equipped with Westinghouse "canned" motor-pumps have a higher unit efficiency, are more reliable and are easier to operate and maintain.

The pump and motor casings completely enclose the pump shafting... Conventional shaft seals and complicated seal injection systems are eliminated.

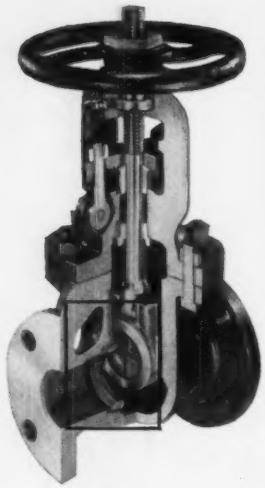
Watertight Inconel cans encase the rotor and stator . . . All windings are dry and clean for years of trouble-free operation.

New unit construction of stator and rotor permits easy, fast (24-hour), in-your-shop inspection, overhaul and repair... Reliability and availability of pumps are at a maximum.

For more information on how Westinghouse "canned" motor-pumps will improve controlled circulation boiler performance, contact your Westinghouse sales engineer, or write Westinghouse Electric Corporation, Atomic Equipment Department, P. O. Box 217, Cheswick, Pa. J-57011

YOU CAN BE SURE...IF IT'S Westinghouse

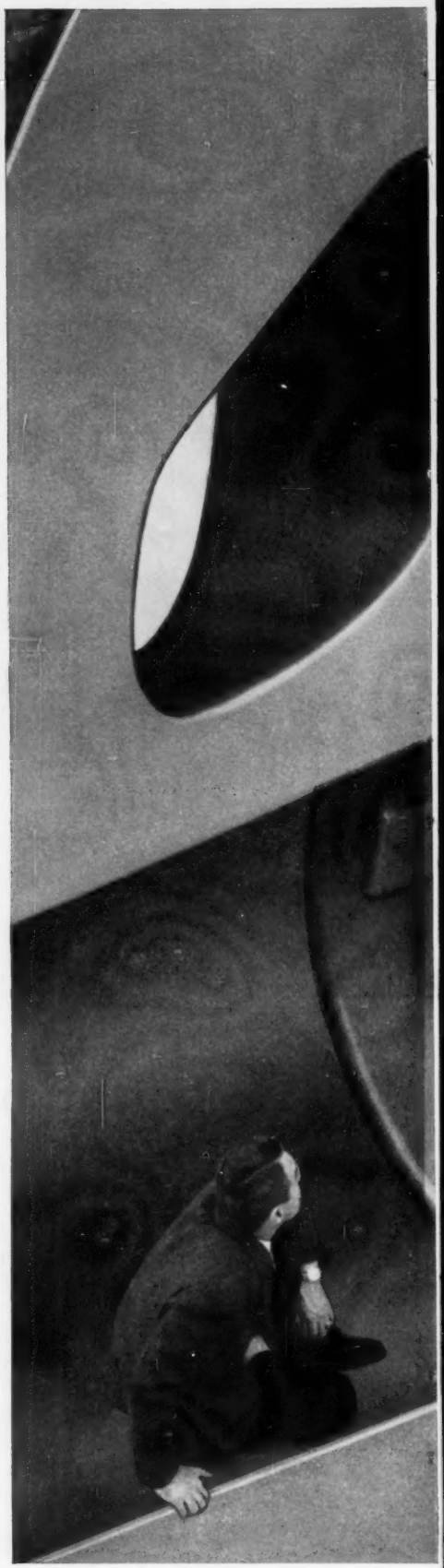
WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

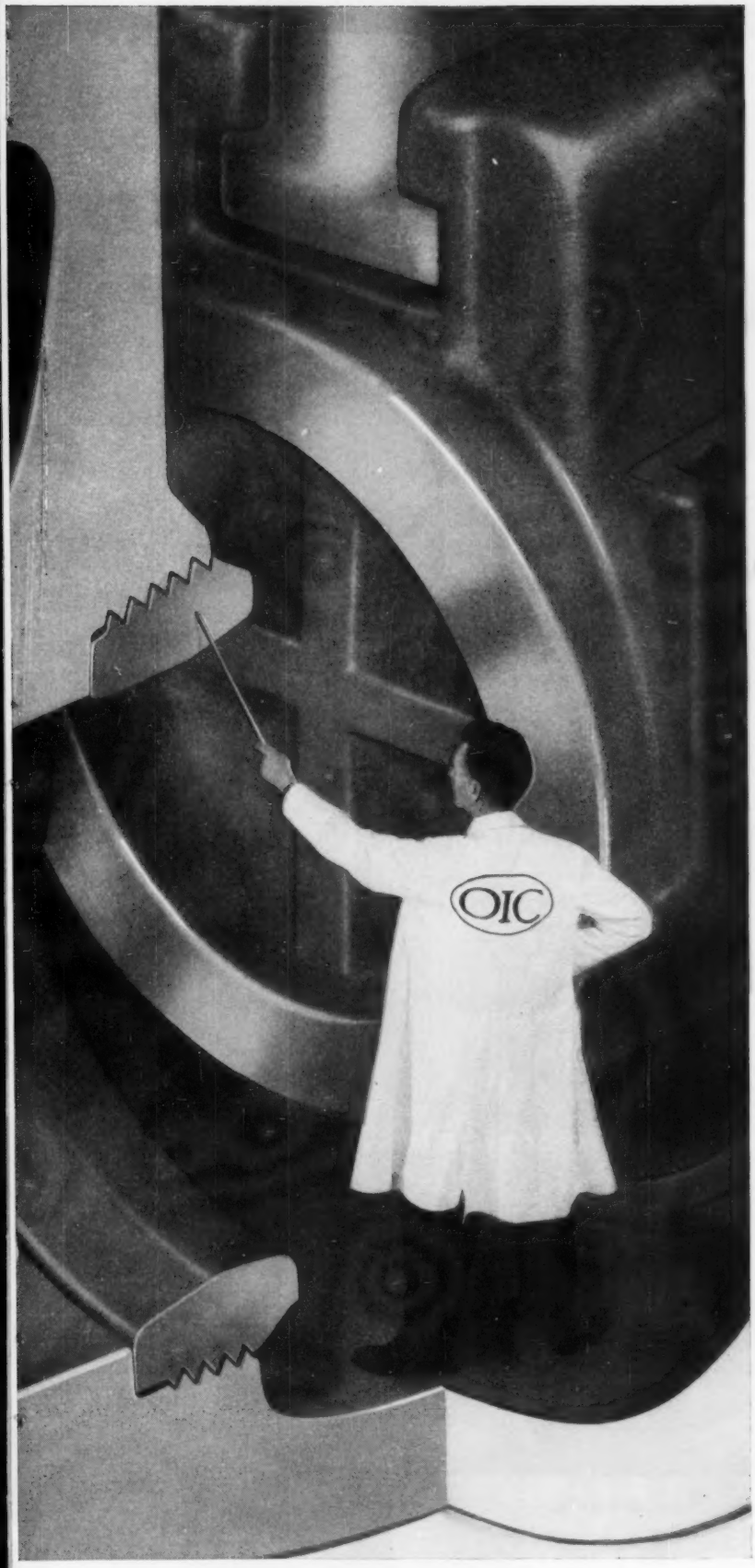


...and here's that same leakproof, streamlined seat ring– a steel valve feature, so good, we put it on our iron valves, too

OIC VALVES

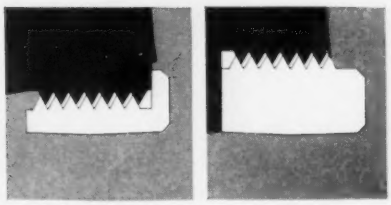
BRONZE, IRON, FORGED AND CAST STEEL LUBRICATED PLUG VALVES





See how this *end*-seated ring fits into the valve body, out of the flow. It streamlines the body port, eliminates excessive pressure drop across the valve.

Here's how these rings reduce your maintenance problems . . .



Old-style, shoulder-seated ring cross section

OIC *end*-seated ring cross section

Old-style *shoulder*-type rings interrupt flow, cause turbulence. Since rings are seated in *tension*, they loosen and leak.

These OIC streamlined rings are *end*-seated in *compression* against the body. They can't loosen, even in continuous operation, so they won't leak.

3 OIC iron valve features that add to your maintenance savings

Yokes in all sizes permit replacement of the yoke nut when the valve is wide open, without interrupting flow.

T-head stem-wedge connection prevents wedge from binding when closing the valve. Closing is easy, positive, least wearing to trim parts.

Threaded backseat bushing seals off upper bonnet of fully open valve. Makes repacking under pressure possible.

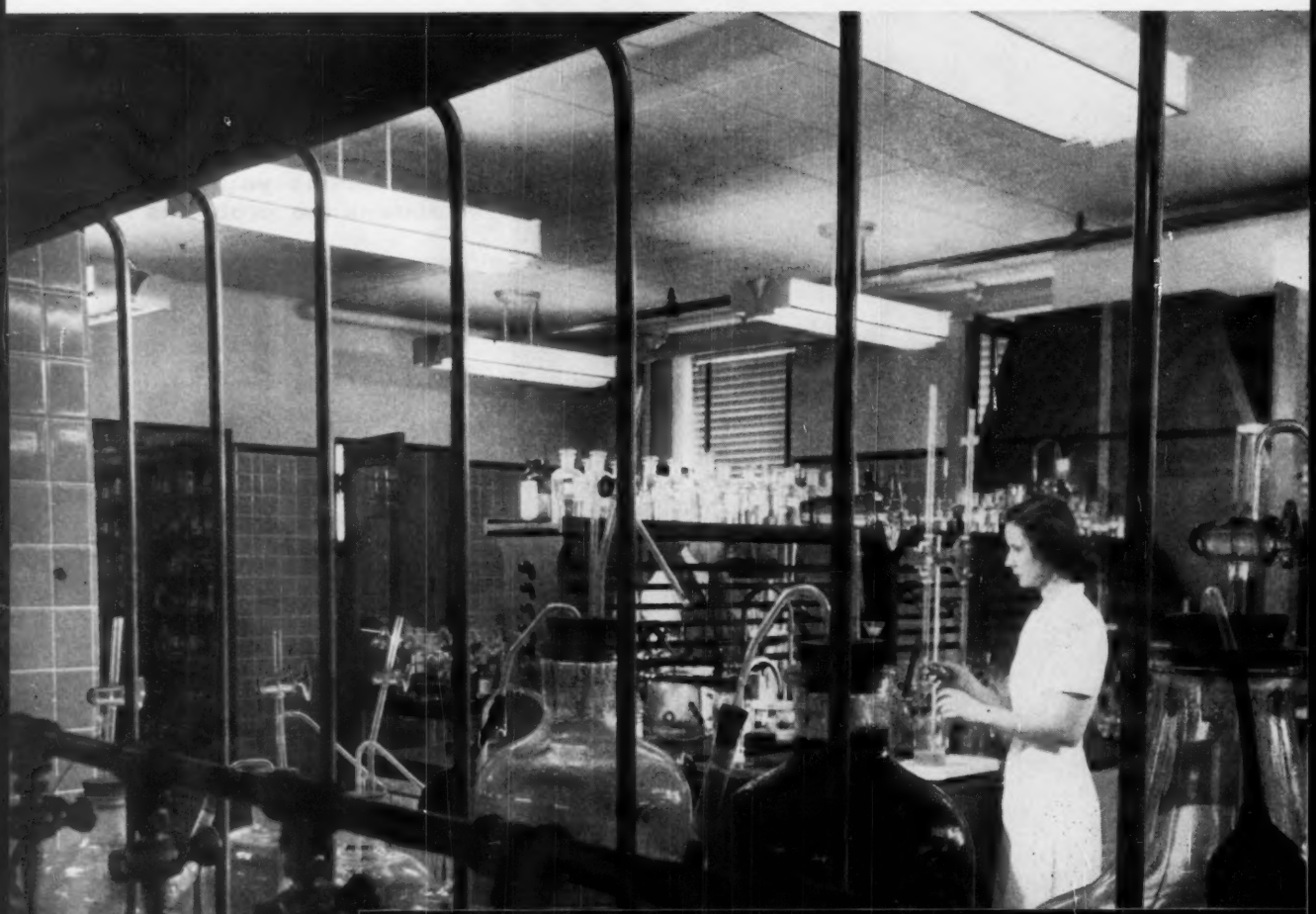
Choose for your service from 29 OIC iron valve numbers with 9 different trim and body metal variations. Order from your OIC Distributor or write for complete specification literature.

THE OHIO INJECTOR COMPANY

WADSWORTH, OHIO

ALLIS-CHALMERS Water Conditioning

One source

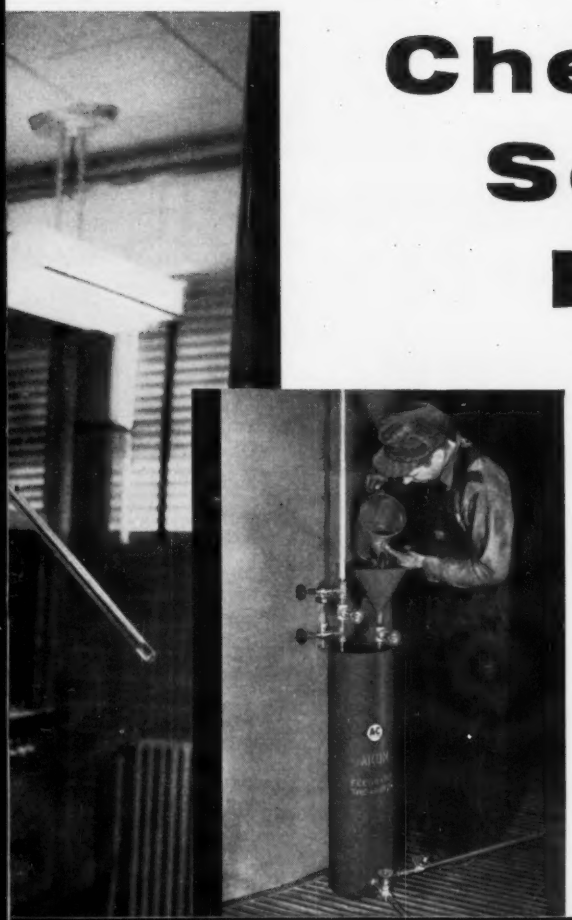


Service...Chemicals...Equipment...

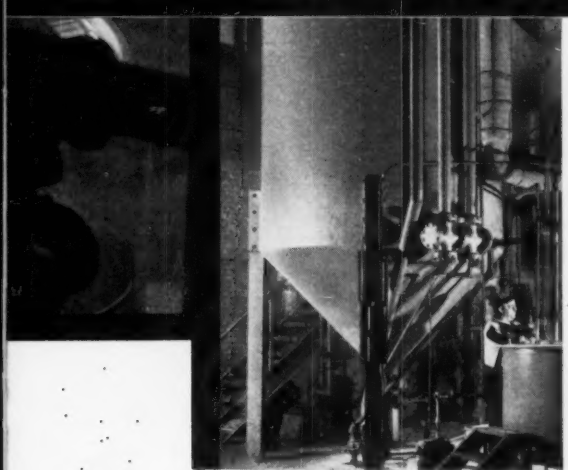
Plan to stay ahead... MODERNIZE!

for

Chemicals... Service... Equipment



backed by RESEARCH



Get the answer to *any* water conditioning problem from one single source — Allis-Chalmers. Whether you need chemicals or equipment, or laboratory service, it is available through an Allis-Chalmers water conditioning engineer.

Whether your problem is scale formations from hardness, foaming from high alkalinity, dirty steam from high concentration of dissolved solids, corrosion from dissolved oxygen, or slime from algae, Allis-Chalmers can provide the answer.

Take advantage of A-C's 30 years' experience in this field. Outline your problem to your nearby A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wis.

A-C ALLIS-CHALMERS

A-5875

ALLIS-CHALMERS

Each of these towers has a capacity of 85,000 gpm, 205 ft. diameter . . . 264 ft. high for two units of 125,000 kw in France.

AIR DRAFT SELF GENERATED INSIDE A REINFORCED CONCRETE STACK
UP TO 350 FEET HIGH
FILLING & HOT WATER DISTRIBUTING NET OF ASBESTOS CEMENT
SUPPORTED BY REINFORCED CONCRETE FRAMEWORK

NO MOTORS
NO GEARS
NO FANS

NO ELECTRIC POWER CONSUMED
NO MECHANICAL MAINTENANCE
NO REPAIRS NOR BREAKDOWNS

ONLY PERMANENT MATERIALS - NO WOOD -
LONG LIFE EXPECTANCY - NO FIRE HAZARDS
NO MAINTENANCE - NO INSURANCE

MISTS DISCHARGED HIGH ABOVE THE GROUND
NO GROUND FOGGING - NO ICE COATING IN SWITCH YARDS
NO RECIRCULATION
EFFICIENCY UNDIMINISHED AT ZERO WIND

HAMON, Inc.

Cable address
ACHAMON, CHICAGO

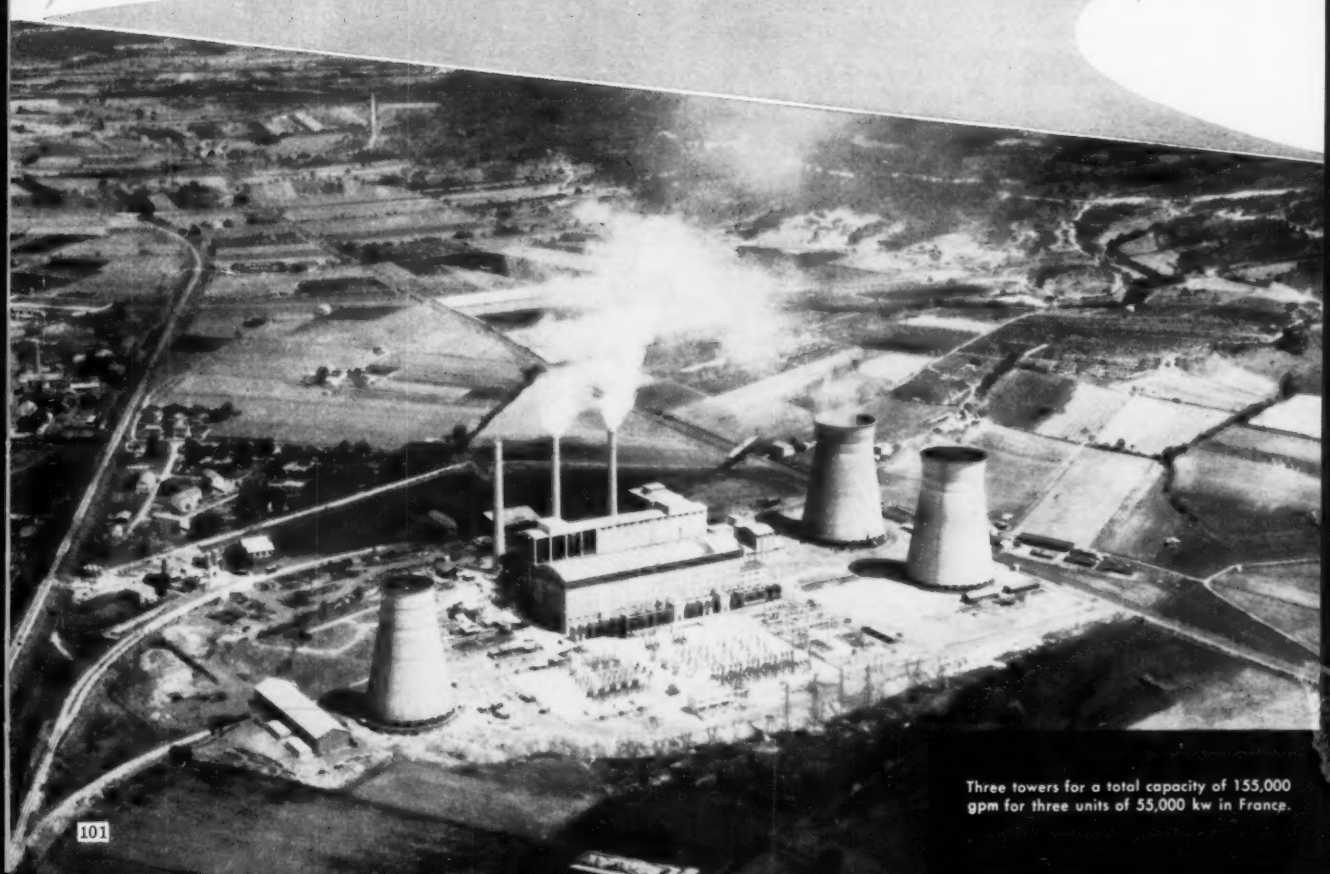
224 South Michigan Avenue
CHICAGO 4, ILLINOIS

Telephone
HARRISON 7 - 0256

HAMON

NATURAL DRAFT COOLING TOWERS

HALF A CENTURY
OF EXPERIENCE!..



Three towers for a total capacity of 155,000 gpm for three units of 55,000 kw in France.

You too can buy with confidence from ERIE CITY

● Erie City . . . pioneer in the development of the 2-drum boiler and the application of water walls to furnace design . . . offers a complete modern line of 2-drum steam generators to solve your most complex steam problems.

Installations such as shown here indicate the versatility and acceptance of the Erie City 2-Drum Steam Generator. The wide range of sizes adapted to all types of mechanical firing prove the adaptability of Erie boilers to all classes of industry. The broad experience of Erie City qualifies it to combine proper boiler selection with efficient use of modern heat recovery equipment and proper application of firing equipment. Add to this the fact that Erie City Generators are designed to include the best of modern utility standards and then you know "*You can depend on Erie City for sound engineering*" . . . is not just a statement. It is a positive fact that will prove to be of value and profit to you.

Some of the Many Users of

ERIE CITY 2-DRUM STEAM GENERATORS

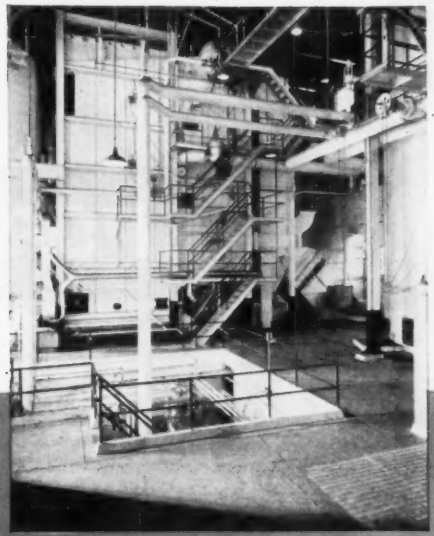
Allied Chemical & Dye Corp.
American Cyanamid Co.
American Steel & Wire Division of U. S. Steel Corp.
Armour & Co.
Ashland Oil & Refining Co.
Continental Motors Co.
Great Western Sugar Co.
International Business Machines Corp.
The Texas Company
Dierks Paper Company
Johns-Manville Corporation
Ford Motor Co.
Gulf Oil Corporation
Hercules Powder Co.
LeTourneau Westinghouse Co.
Minnesota Mining & Manufacturing Co.
Monsanto Chemical Co.
Northern Chemical Industries, Inc.
Northwestern University
Ohio State University
Olin Mathieson Chemical Corp.
Tidewater Associated Oil Co.
U. S. Atomic Energy Commission
Woodward Iron Co.

ERIE CITY
Since 1840

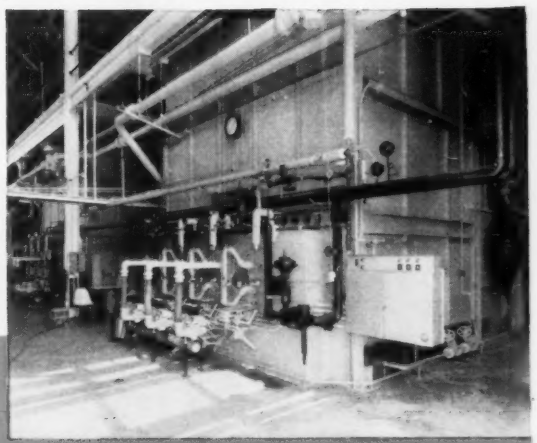
You can depend on Erie City for sound engineering

ERIE CITY IRON WORKS · Erie, Pa.

STEAM GENERATORS • SUPERHEATERS • ECONOMIZERS • AIR PREHEATERS
WASTE HEAT BOILERS • FIRE and WATER TUBE PACKAGE BOILERS
OIL and GAS BURNERS • STOKERS • PULVERIZERS



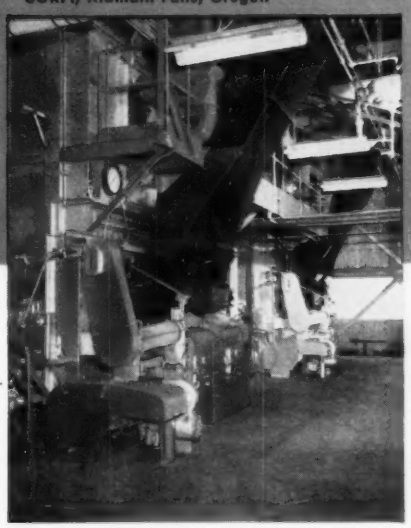
2—150,000 #/hr. Erie City 2-drum Steam Generators, stoker fired, at GREAT WESTERN SUGAR CO., Longmont, Colorado



2—70,000 #/hr. Erie City 2-drum Steam Generators, oil and gas fired, at INTERNATIONAL BUSINESS MACHINES CORP., Rochester, Minnesota

1—150,000 #/hr. Erie City 2-drum Steam Generator, oil and gas fired in a pressurized furnace, at THE TEXAS CO., Lockport, Illinois

2—65,000 #/hr. Erie City 2-drum Steam Generators, stoker fired with coal and wood waste, at JOHNS-MANVILLE PRODUCTS CORP., Klamath Falls, Oregon



1—50,000 #/hr. Erie City 2-drum Steam Generator, gas fired, at DIERKS PAPER CO., Pine Bluff, Arkansas

A REPORT:

This is growth . . .
healthy growth . . . and a
credit to the power industry.

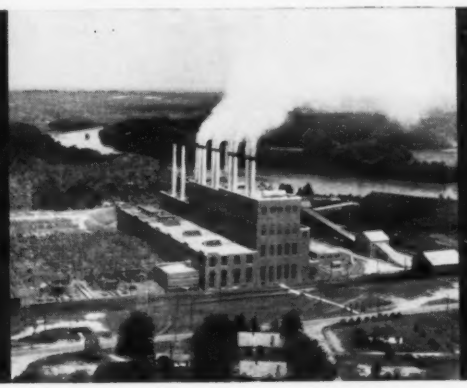
For the past half-century, the Duke Power Company has been serving the Piedmont Carolinas. Today this utility, covering a 20,000 square mile area, has 7 steam and 32 hydro-electric plants with a generating capacity of nearly 2¾ million kilowatts . . . 12 billion kilowatt hours a year. More than ½ million customers are being supplied with instant, dependable power for light, protection and comfort . . . reliable power for successful farming and progressive industry. And the Duke Power Company is expanding rapidly. New units are being constructed constantly. An investment of about $30,000,000. annually goes into this expansion program to service a fast growing area.

Every one of the present 39 power stations now operating this system was designed, constructed and developed by the Duke Power Company engineers. Each plant has been kept modern in every respect. And every one of these stations uses Chapman Valves. Chapman Valves have been used by this system since the turn of the Twentieth Century. They have been used for many sound and practical reasons.

Chapman steel valve . . . 16″ x 14″ x 16″ . . . pressure seal type, 1500 lb. series. Chapman is constantly supplying growing industries with valves for increasingly high pressure and temperature service.

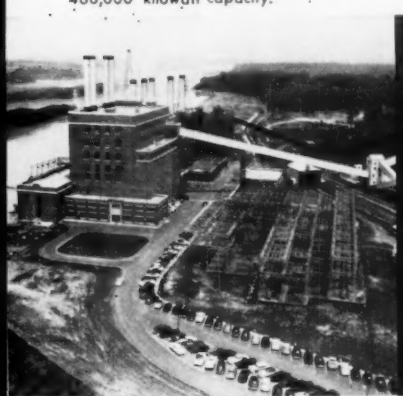
on the Duke Power Company and Chapman Valves

Above: Cliffside units 1, 2, 3, 4. Total kilowatt capacity 220,000.
Below: Buck units 1, 2, 3, 4, 5, 6. 460,000 kilowatt capacity.



Above: Riverbend units 1-7 with a total capacity of 665,000 kilowatts.
Below: Dan River units 1, 2 and 3. 300,000 kilowatts total capacity.

Above: Allen Steam Plant — Two additional units now under construction.
Below: Lee units 1 and 2. 385,000 kilowatts. Unit 3 opens December 1958.



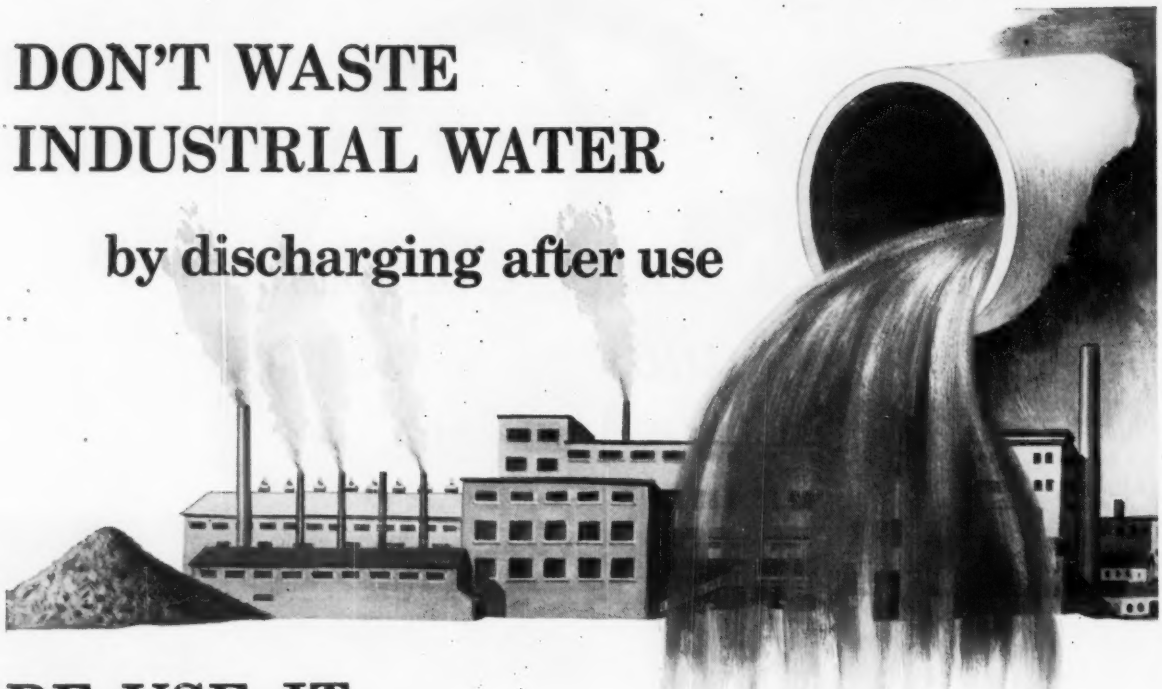
The CHAPMAN VALVE

Manufacturing Company INDIAN ORCHARD, MASSACHUSETTS

Study the record of The Chapman Valve Manufacturing Company for the past 75 years and you'll find the many reasons why Chapman Valves are used by Duke Power and many other important Companies in many fields of endeavor. Chapman designs, develops, produces and delivers valves — that meet the requirements of today and of tomorrow. A consultation between Chapman engineers and yours, with no obligation to you, is sincerely recommended. Simply write . . . today, anytime, soon.

DON'T WASTE INDUSTRIAL WATER

by discharging after use



RE-USE IT

by clarifying with Celite filtration

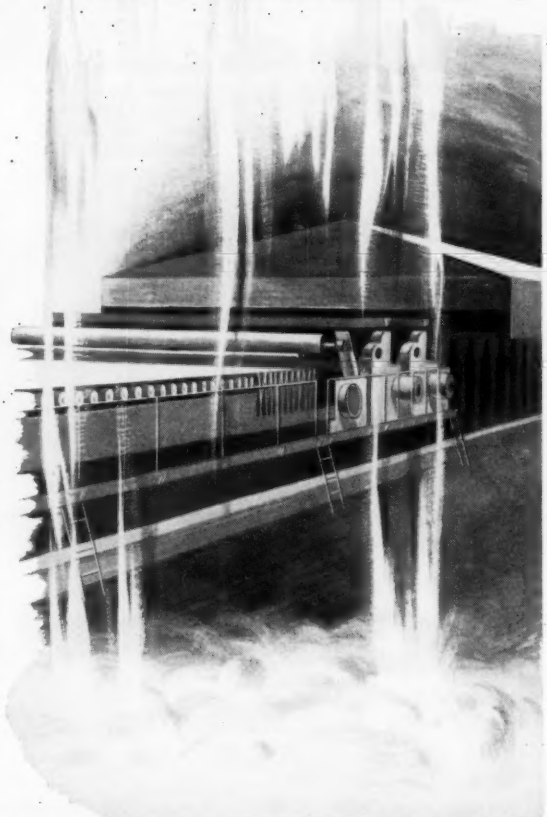
Recycling your process water instead of discharging it makes good sense in four important ways:

1. It cuts your water costs.
2. It conserves your community's water supply.
3. It helps you meet the high sanitation standards now imposed in many areas.
4. It protects your local rivers and streams from pollution . . . preserves these waterways for recreational purposes.

It also makes good sense to use Celite* diatomite for clarifying this plant waste. Celite filtration removes more suspended solids, including amoebae, algae and most bacteria. It operates at fast flow rates with any conventional pressure filter. It comes in 9 standard grades for precise clarity control. And it is low in cost.

A Celite engineer will be glad to study your water problem and offer recommendations with no obligation. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products



Johns-Manville CELITE diatomite filter aids

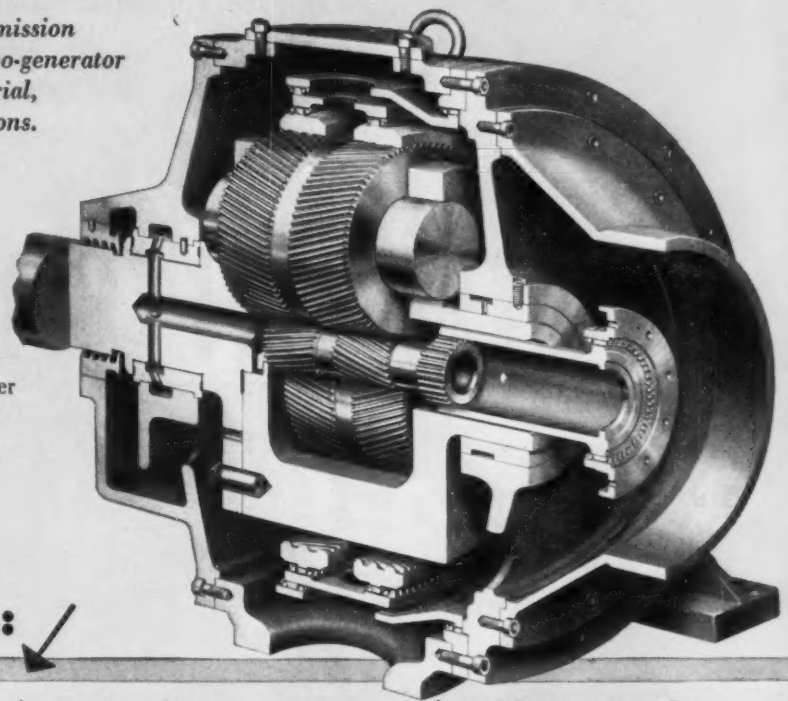
DE LAVAL-STOECKICHT
PLANETARY GEAR

...for high speeds...high horsepower

Proved in hundreds of installations abroad totalling over 3,000,000 horsepower—now available in America!

For all high torque power transmission applications such as pump turbo-generator and compressor drives in industrial, municipal and marine installations.

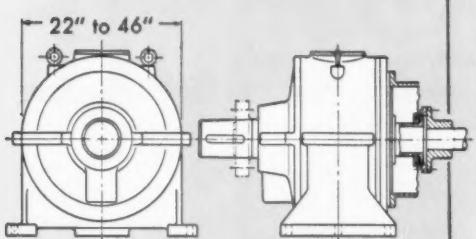
This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)... no high speed bearings... less friction losses.



Check These Advantages:

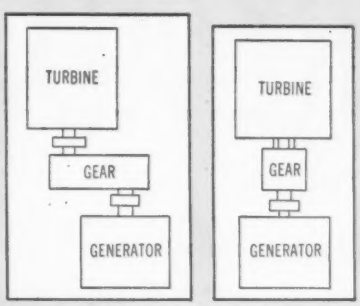
Small Size—Light Weight

Compact—low weight per hp. Sizes range from 22" to 46" in diameter, depending on horsepower requirements. Example: 5000 hp planetary unit weighs 1700 lbs. against 6000 lbs. for conventional gear.



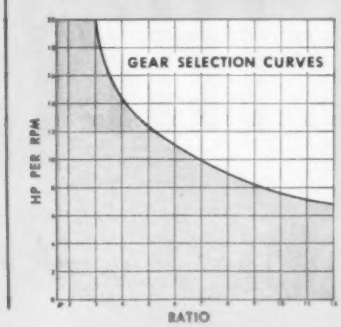
Convenient Arrangement

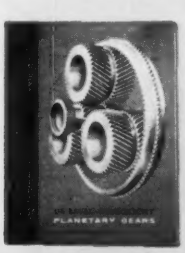
Co-axial or "in-line" arrangement of gear members takes up far less space than parallel axis gears of equivalent horsepower rating.



Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.





For further details, write for Bulletin 2400.

DE LAVAL *Steam Turbine Company*

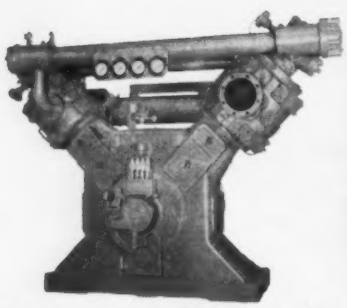
815 Nottingham Way, Trenton 2, New Jersey

DL431

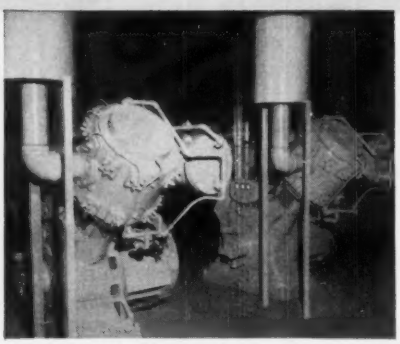
TYPE Y COMPRESSORS

- *75 to 250 horsepower*
- *For vacuum service and pressures to 5,000 pounds*
- *One to four stages of compression*
- *Built-in motor, coupled, and belt drive*
- *Simple, compact, widely adaptable, heavy-duty*
- *Built for "round-the-clock service" with minimum of attendance*

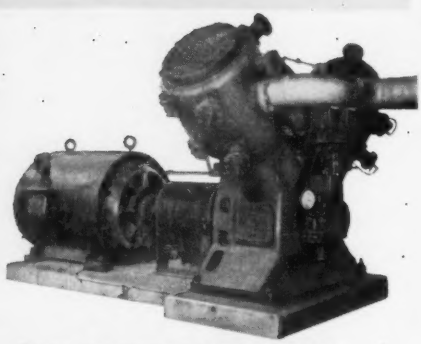
word for the Y's...



Four-stage high pressure unit available with flange-mounted, belted, or coupled drive.



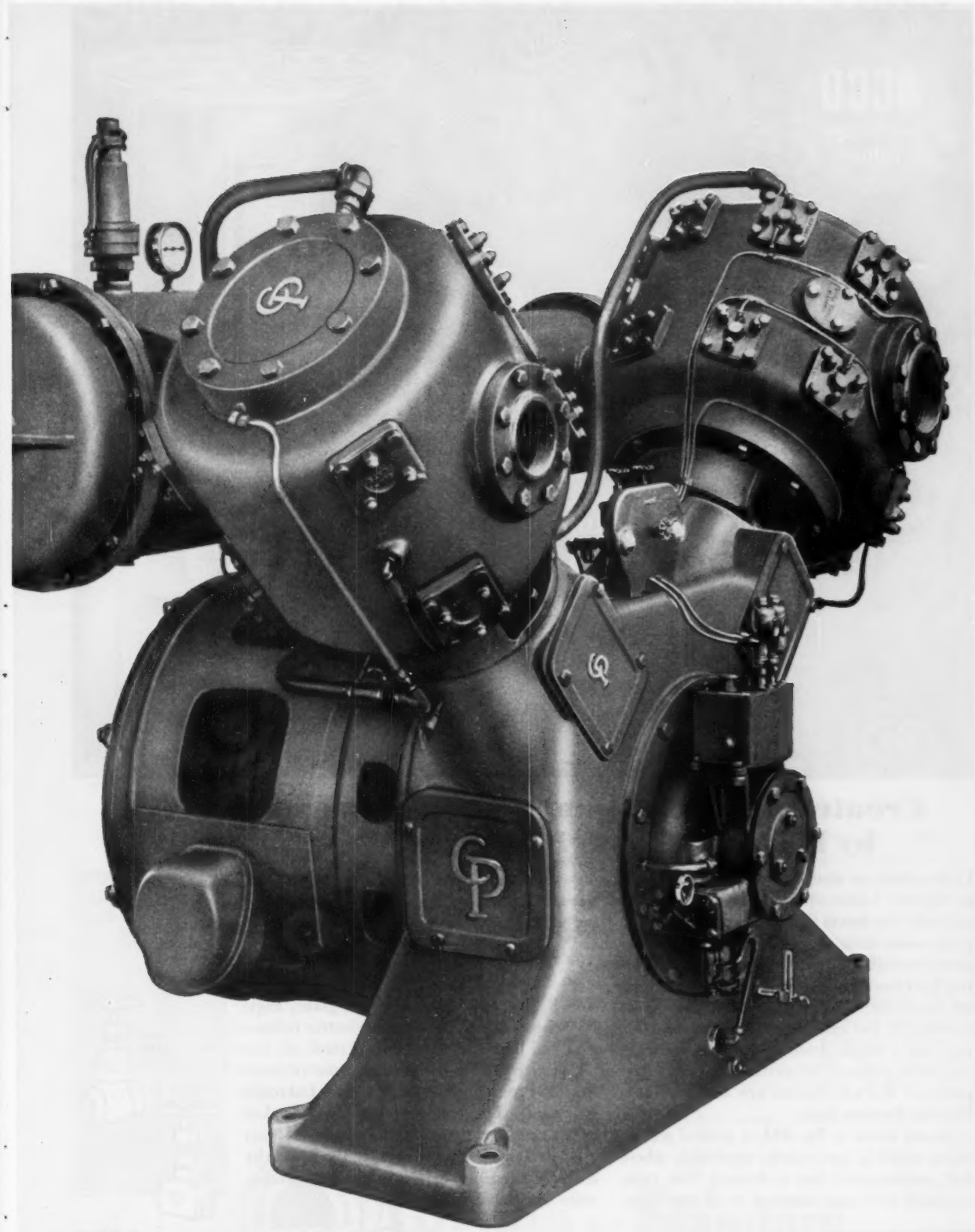
Non-lubricated, two-stage compressor, with built-in motor, provides oil-free air for process work.



Butane compressor, direct coupled to an explosion-proof motor, in a prominent refinery.

THEY'RE ADAPTABLE

★ OTHER TYPE COMPRESSORS AVAILABLE
IN SIZES TO 5000 HP AND PRESSURES TO 15,000 PSIG.



Chicago Pneumatic 8 East 44th Street, New York 17, New York

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

ACCO
for Better
Values

R-P&C VALVES

THE COMPLETE LINE
—DESIGNED FOR DEPENDABILITY

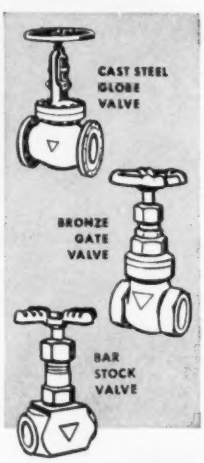
Created by R-P&C—made and sold exclusively by R-P&C...Electric Furnace Iron Valves

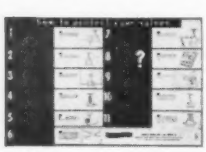
Electric furnace iron—introduced exclusively in R-P&C Valves—provides a high quality cast iron that meets the exacting requirements for pressure castings. Melted and refined under closest metallurgical supervision, R-P&C Electric Iron has physical properties *far exceeding the minimum standards* to which they must conform. It has a balanced chemical composition and a tough, dense body structure; and, it is more resistant to corrosion. All cast iron parts of R-P&C Valves are made of this Electric Furnace Iron.

Shown above is **Fig. 625**, a general service valve which is particularly applicable where full, unobstructed flow is desired. This type, available in bronze-trimmed or all-iron style, either flanged or screwed, is made in fifteen sizes, from 2″ to 24″—and is typical of the better values offered by the entire line of R-P&C Electric Iron Valves.

The R-P&C Line is Complete

The R-P&C line embraces gate, globe, angle and check valves in bronze, electric furnace iron and cast steel, and forged steel; all in a wide range of sizes, styles and pressure classes. Also, R-P&C offers specialties such as Lubrotite gate valves, bar stock valves, asbestos-packed cocks, cast steel fittings and pressure-seal cast steel valves. Order through your nearby R-P&C Distributor. For complete catalog, write our Reading office.





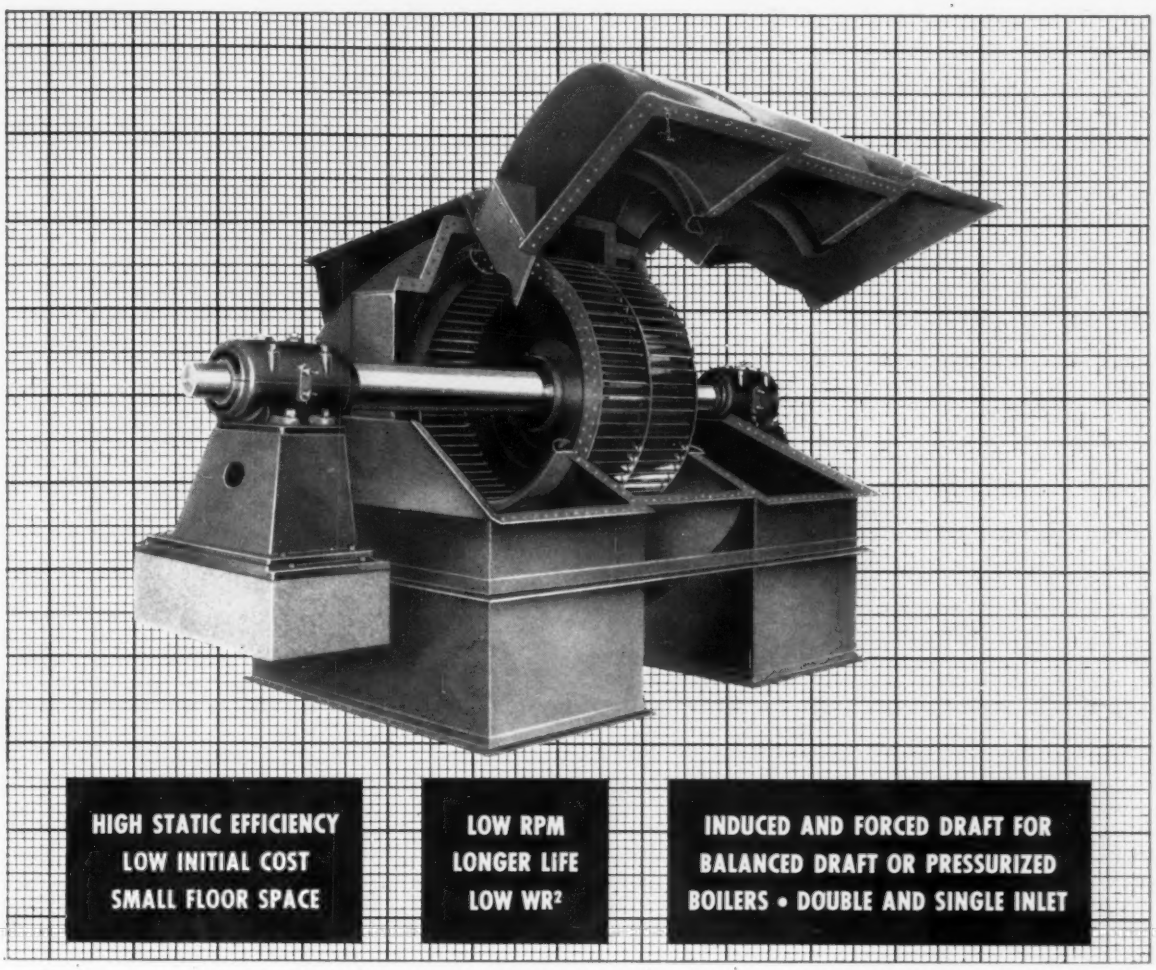
FREE WALL CHART
"How to Protect Your Valves"
Installation pointers, operating tips, clues to longer valve life. They are all on this 22″ x 17″ wall chart. Write for your free copy.

R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

ACCO

AMERICAN BLOWER SIROCCO FANS



HIGH STATIC EFFICIENCY
LOW INITIAL COST
SMALL FLOOR SPACE

LOW RPM
LONGER LIFE
LOW WR²

INDUCED AND FORCED DRAFT FOR BALANCED DRAFT OR PRESSURIZED BOILERS • DOUBLE AND SINGLE INLET

Look for low initial cost, reduced operating costs, guaranteed performance ratings, minimum maintenance and space requirements. You'll find them *all* in American Blower Sirocco mechanical draft fans.

Specially designed for induced-draft and forced-draft work, Sirocco Fans feature die-formed, forwardly inclined blades for high static efficiency at low rpm's. Streamline, low-turbulence inlets also contribute to high efficiency. And for longer service life, Sirocco Fans have heavy-duty rim and hub plate construction . . . heavy, steel-plate housings and inlets. Special erosion-resistant features are available, as well.

For high efficiency, low cost over the entire operating range, couple Sirocco Fans with American Blower *Gyrol*® Fluid Drive. Infinitely variable in speed, Gyrol Fluid Drive matches fan speed to boiler demand; pays off in longer life for fan wheels and bearings; quieter operation.

If you are investigating mechanical-draft equipment for new or existing installations, take advantage of our experience in air handling. Call your nearby American Blower branch office, today. Or write: American-Standard,* American Blower Division; Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard Products

AMERICAN-Standard

AMERICAN BLOWER DIVISION

LADISH

...THE RECOGNIZED, DEPENDABLE SOURCE FOR

18" alloy steel elbows with 3.9" wall for extremely high pressure-temperature service.

Heavy wall laterals closed impression die forged of Stainless Steel in a variety of sizes.

Stainless Steel, heavy wall, reducing tee with extended run section.

Stainless Steel Elbow with heavy wall and special radius for nuclear service.

Seamless and welded rolled rings produced in sizes to 20 feet in diameter . . . in rectangular and contour cross sections . . . in all forgeable material specifications . . . to meet critical requirements of reactor installations.

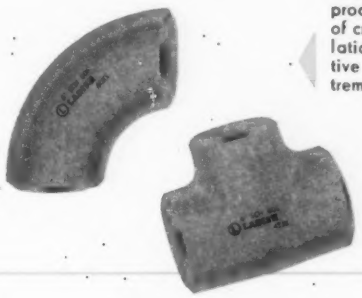
16" x 16" x 20" forged Chrome-Moly bull-head tee with special flow dividing throat section opposite the branch.

Heat exchanger tube sheet of Stainless Steel. Forged weight — 4220 pounds.

Unusual Fittings

FOR NUCLEAR AND CONVENTIONAL POWER PIPING APPLICATIONS

Type 304L Stainless Steel Nozzle, drop forged and machined to precision tolerances.



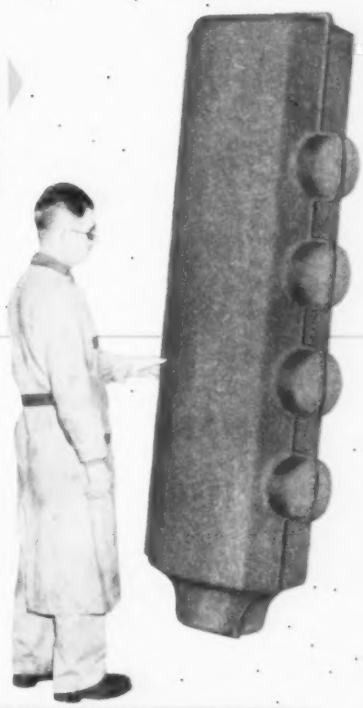
Titanium pipe fittings produced for a number of critical piping installations requiring positive resistance to extremely corrosive media.

Ladish is widely recognized as a prime, dependable source for a broad range of special-purpose fittings and forgings to meet unusual piping problems.

The fittings shown here were developed in close collaboration with the engineering staffs of firms pioneering in the design of modern conventional power plants and nuclear power installations.

Ladish has extensive experience and unequalled facilities for forging, machining and testing . . . small and large, simple and complex parts, in virtually every forgeable material . . . under precise metallurgical and manufacturing controls.

Largest closed impression die forging produced to date. Weight — 10,500 pounds . . . 316 Stainless Steel. For use in modern power plants operating at elevated pressures and temperatures.



TO MARK PROGRESS

Intricately shaped Stainless Steel heat exchanger heads. Drop Forged and machined to close tolerances by Ladish.

LADISH CO.

CUDAHY (Milwaukee Suburb) WISCONSIN

Serving the West . . . Ladish Pacific Division, Ladish Co., Los Angeles, Calif.
Serving Canada . . . Ladish Co. of Canada Ltd., Brantford, Ontario

Complete Service in *Controlled Quality* Fittings

WELDING FITTINGS	ASA & MSS FLANGES	SCREWED and SOCKET FITTINGS and UNIONS	LONG NECK FLANGES	TEMA & LARGE O.D. FLANGES & ROLLED RINGS

SECONDARY UNIT SUBSTATIONS

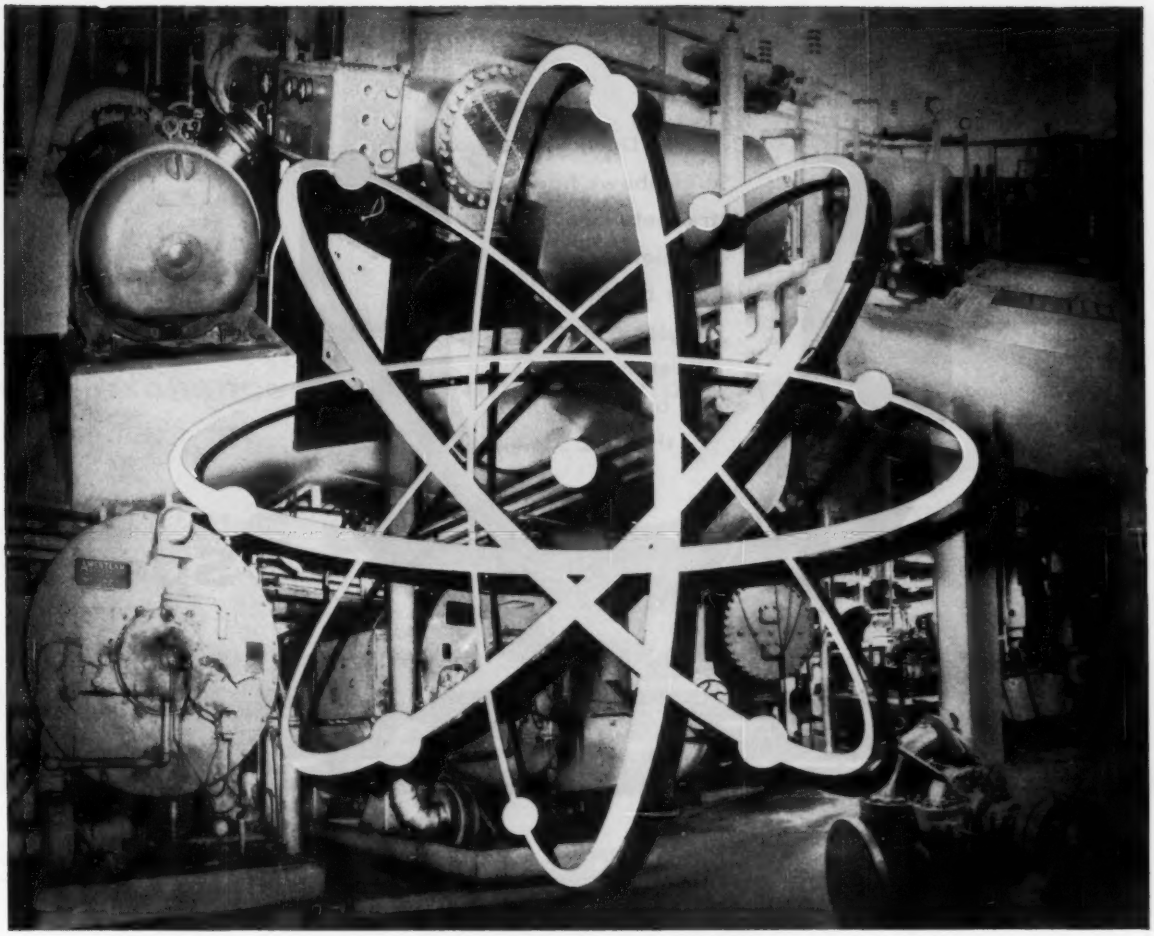
① **Incoming Section:** Terminal chambers; disconnecting and interrupter switches; roof bushing; metal-clad type HV/switchgear. ② **Transforming Section:** Askarel or oil-immersed type transformers; ventilated dry type transformers; sealed dry type transformers. All manufactured at I-T-E in Philadelphia. ③ **Outgoing Section:** The new K-Line of low voltage switchgear featuring manually charged or motor charged stored energy quick-make circuit breakers, and all with the closed door drawout feature.

I-T-E assumes all responsibility for your substation requirements

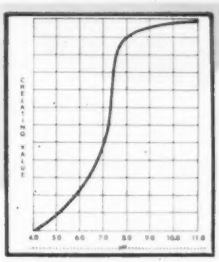
When you place an order for an I-T-E secondary unit substation, you can forget detailed planning, paperwork and the problems of coordinating delivery. I-T-E assumes complete responsibility. It engineers the unit to meet your requirements. It builds the transformers and switchgear. It assembles the complete unit under one roof, testing it to assure ease of installation and top performance. It ships the unit *as one package*, from one location, and ready to install.

Typical of the extra values found only in I-T-E secondary unit substations is the new quick-make K-Line of low voltage switchgear. A manually charged mechanism in each circuit breaker stores energy in the first 90% of pulldown handle travel, releases it in the last 10%. It also features racking to all positions—connected, test and disconnected—while doors are closed. Both features greatly increase operator safety and reduce maintenance problems. I-T-E secondary unit substations can be supplied for any application, indoor or outdoor, and in any standard rating. For details, contact the I-T-E sales office nearest you. Or write Switchgear Division, I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Phila. 30, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ontario.

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA • PENNSYLVANIA



MOGUL *Chelating adds another BIG plus to plant water treatment



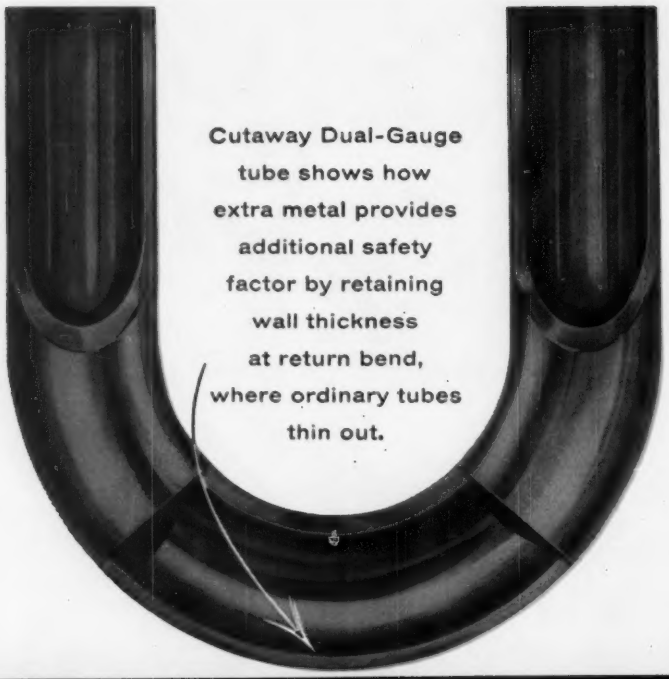
The North American MOGUL Products Company

Standard Building • Cleveland 13, Ohio

Mogul chelating agents (*pronounced key-late-ing) are the newest advancement in plant water treatment technology. The chelating formulas represent another step in MOGUL-IZING to provide safe and economical plant operations. Chelating compounds actually combine with metallic ions to form stable soluble combinations that, in effect, isolate the metallic ions. These combinations are stable over a wide range of temperature, pH and concentration. In boilers, water supply systems, cooling towers and evaporative condensers where higher pH values develop, chelating agents are most effective as shown in the graph.

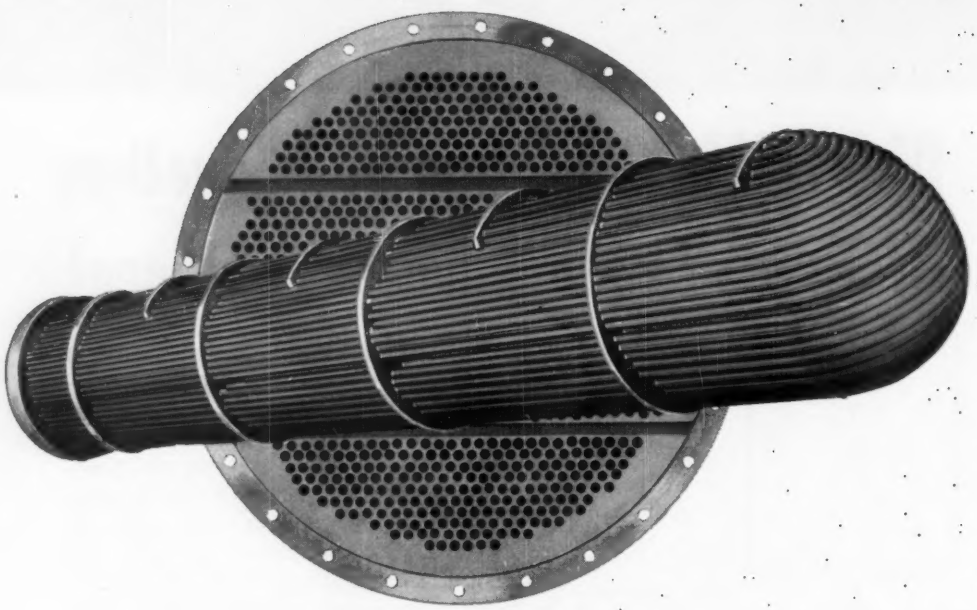
Write direct for complete information on how chelating might help you in your plant water treatment problems.

SPECIALISTS IN INDUSTRIAL WATER TREATMENT FOR OVER 40 YEARS



Specify

DUAL-GAUGE



First for Lasting Quality—from Mine to Market!

To keep tubes uniformly strong
in condensers, feed water heaters,
heat exchangers and similar equipment . . .

PHELPS DODGE

TUBING!

Provides heavier wall thickness:

a. At one or more points in tube length to compensate for thinning on outer portions of return bends.

b. At points of support.

c. At tube ends to meet special requirements.

Produced in all standard sizes or manufactured to the particular design requirements of individual customers.

Available in Cupro-Nickel, Red Brass, Aluminum Brass, Admiralty metal and Muntz metal.

PHELPS DODGE COPPER PRODUCTS CORPORATION
MINE TO MARKET
REG. U.S. PAT. OFF.

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Cambridge, Mass., Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Dayton, Detroit, Fort Wayne, Greensboro, N. C., Houston, Indianapolis, Jacksonville, Kansas City, Mo., Los Angeles, Memphis, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

You can't buy a better flange...

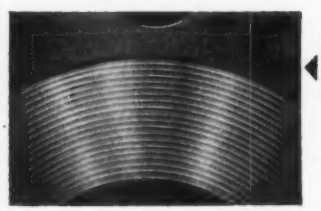
Forged Steel. Shot Blasted. All Phoenix flanges meet full A.S.A. specifications — carbon steel and alloy.

Spot faced bolting surfaces, extra fine facings, accurate threading and a protective coating are typical of Phoenix quality.

Precisely machined welding bevel.

Special facings, bores, drilling, threading and special machining available.

The long life and precision workmanship you have a right to expect in the flanges you buy are assured when you order Phoenix forged steel flanges. You simply can't buy a better flange! It costs no more for Phoenix quality and *service*. That's why it's always worthwhile discussing your pipe flange requirements with the Phoenix representative.



A serrated gasket surface finish is standard on all Phoenix flanges with raised facings.

Write for handy 36 page pocket-size reference booklet containing useful data on flanges. It's FREE!

Leading Manufacturers of Pipe and Tank Flanges and Commercial Forgings

PHOENIX

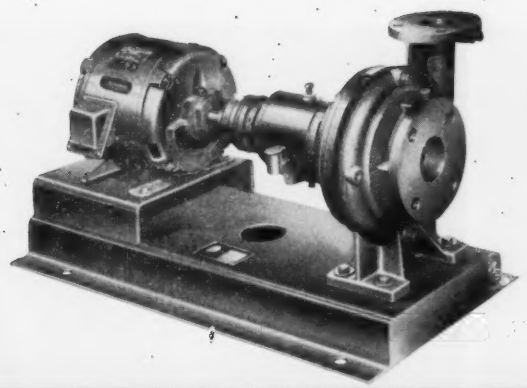
FLANGE AND FORGING DIVISION

PHOENIX MANUFACTURING COMPANY

DIVISION — UNION TANK CAR COMPANY

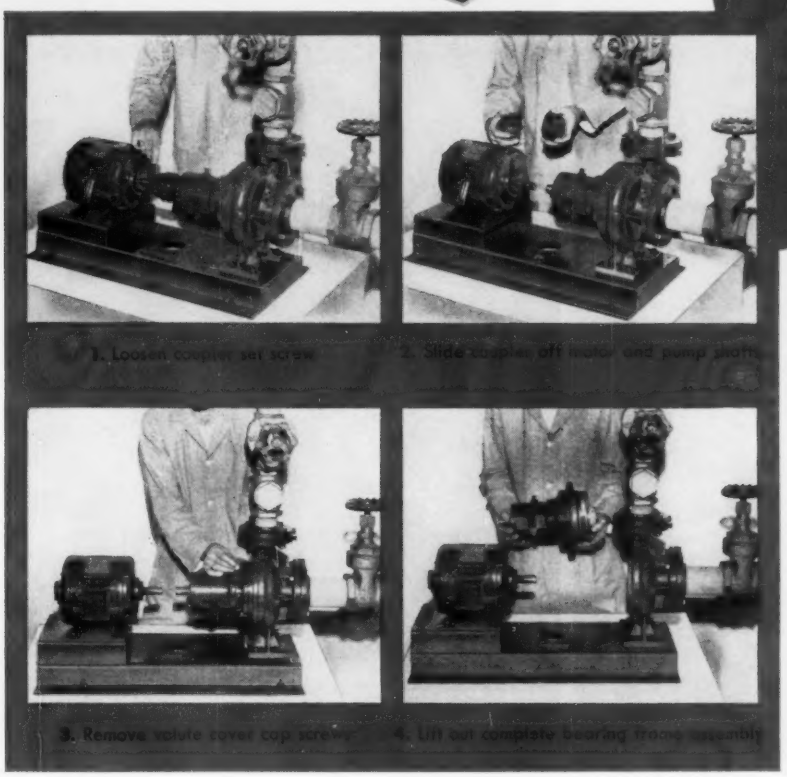
CATASAUQUA, PA. • JOLIET, ILL. • FOUNDED 1882

PHOENIX DIVISIONS: FLANGE AND FORGING DIVISION, STEEL MILL DIVISION, HORSESHOE PRODUCTS DIVISION, FABRICATING REBAR DIVISION



EASY TO SERVICE THIS VERTICAL SPLIT-CASE PUMP

B&G SERIES 1510-B CENTRIFUGAL PUMP


1. Loosen coupler set screw
2. Slide coupler off motor and pump shafts
3. Remove volute cover cap screws
4. Lift out complete bearing frame assembly

The photos show how easily the complete bearing frame, including seal and impeller, can be removed without disturbing piping or motor leads. The unit is replaceable and interchangeable in all pump sizes within limits of material construction.

Other features of the 1510-B include—

Mechanically balanced impeller. Balancing chamber and pressure relief holes in the impeller reduce thrust to a minimum, lengthening pump life.

Solid-type volute with support foot. Can be left in pipe line when servicing pump—rugged construction absorbs piping strains.

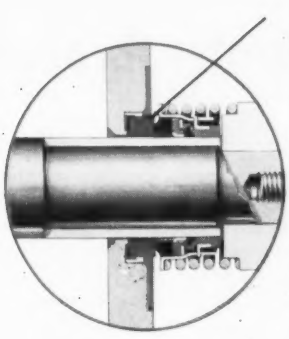
Anti-friction roller bearings. Timken bearings handle thrust and radial loads for smoother, quieter, more efficient operation.

Oil lubrication. No messy, undependable grease cups—circulating oil lubrication assures positive protection to bearings. Oil level indicator permits visual check.

Rugged steel base. Base mounted construction provides a sturdy platform for proper pump and motor alignment.

100% factory tested. Every pump hydraulically tested to meet specified conditions of head and capacity.

Capacities. To 1100 GPM, heads to 420 ft.



LEAK-PROOF "REMITE" SEAL

This exclusive feature assures long, trouble-free life—eliminates the customary leakage which occurs when a packing gland is used. A carbon seal ring faces on a "Remite" floating seat—a material developed by B&G, so hard it will scratch glass—wear-proof and corrosion-resistant.

This mechanical seal is self-lubricating. A synthetic rubber bellows seals the shaft. Metal parts are of steel, bronze or stainless steel, depending upon the type of service.

STOCK PUMPS FOR QUICK SERVICE

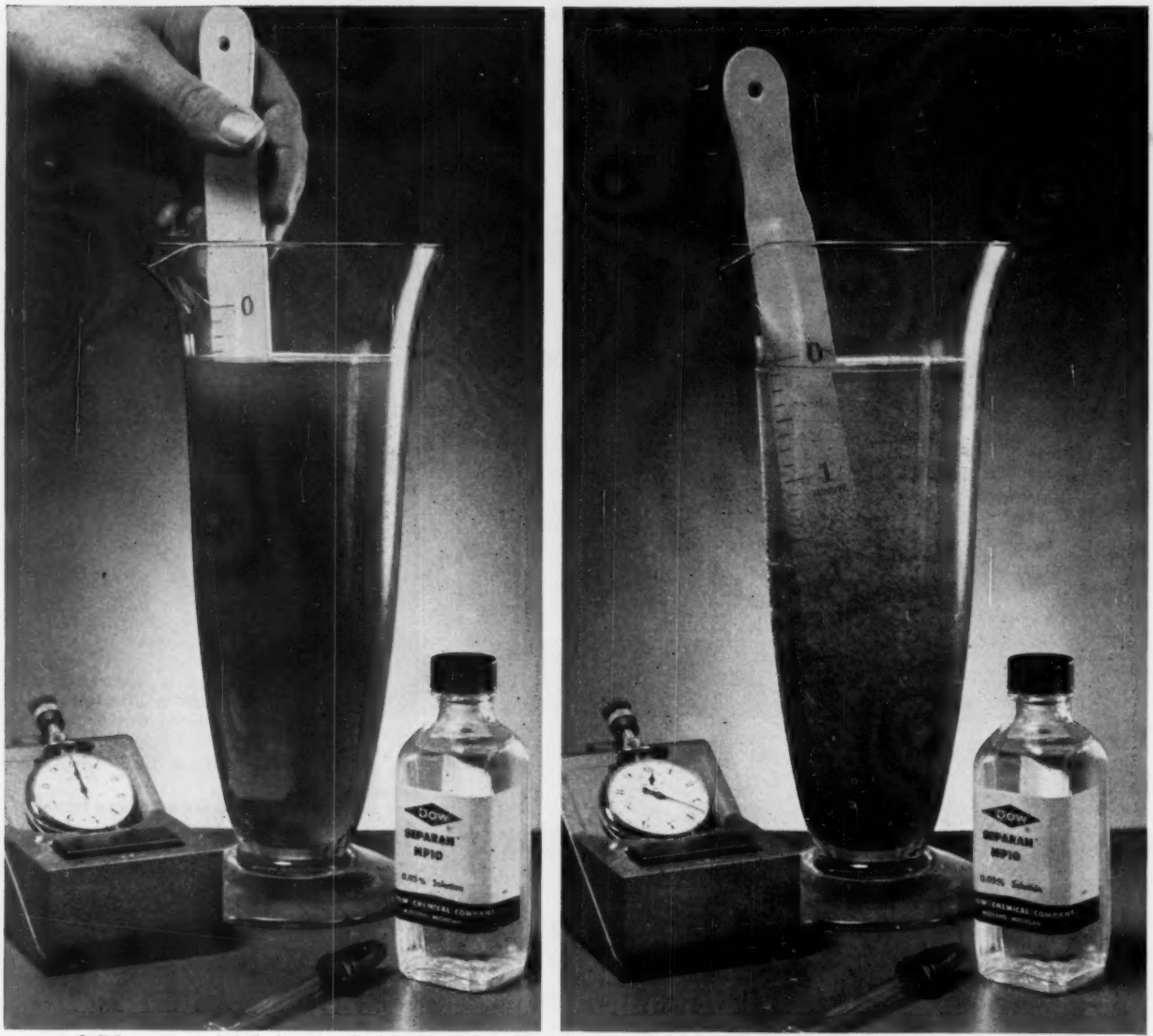
Selected sizes of B&G Series 1522, 1531 and 1510-B Centrifugal Pumps are stocked at the factory for immediate shipment. Capacities to 225 GPM, heads to 140 ft. Send for Price and Selection Catalog.

BELL & GOSSETT COMPANY

Dept. FN-36, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto 16, Ontario

Reg. U.S. Pat. Off.



Solids content 0.2% by weight (sample taken from Saginaw River, Saginaw, Michigan). ¼-½ ppm 0.05%

Separan flocculants speed process water throughput . . .

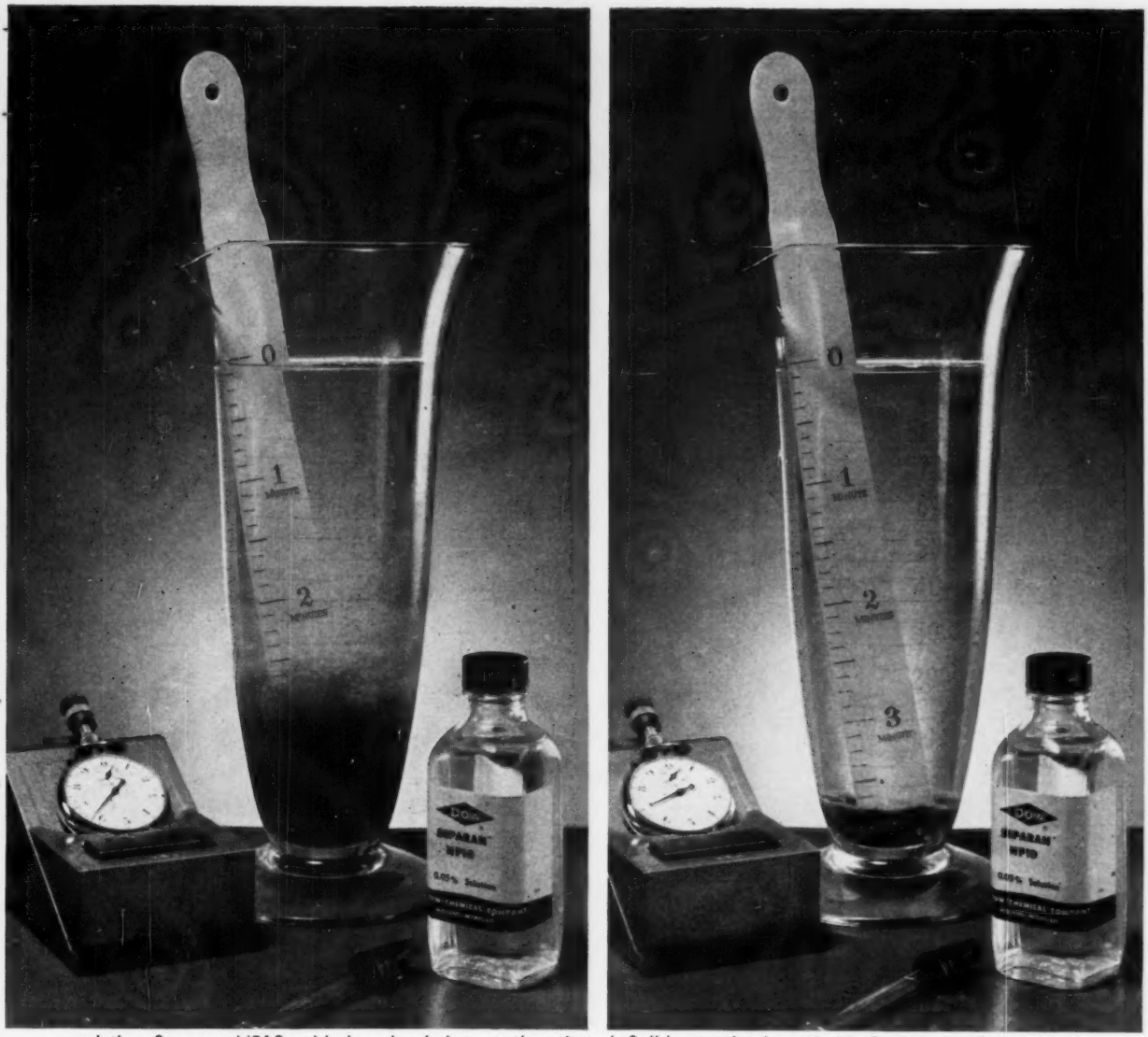
Dow's new high-powered flocculating agents, Separan® NP10 and NP20, are used by many engineers to clarify water for processing or cooling purposes—in a fraction of the time required with other flocculants!

Two particular characteristics make Separan flocculants very valuable. First, the speed with which they act. Second, the quality of the floc formed.

These properties speed sedimentation, filtration, clarification, softening and recovery operations under a wide range of pH conditions. No special equipment is needed. Separan flocculants are added to other flocculants (e.g. alum, ferric chloride) to enable the settling job to be accomplished in a fraction of the time normally required. Separan flocculants are synthetic, organic products—easy to disperse, easy and safe to use, noncorrosive. They are effective over a wide temperature range, require no heat or preservative.

Dow Stressing Flocculant Research. Separan NP10 (improved form of Separan 2610) and Separan NP20 may soon be joined by other new flocculants for specific uses.

Dow can help you trim your water treatment costs with flocculating agents, ion exchange resins and chelating agents. Contact your nearest Dow sales office for detailed information. Quantities of Separan flocculants are immediately available for your own testing and evaluation. THE DOW CHEMICAL COMPANY, Midland, Michigan, Engineering Chemicals Department 1057E-2.



solution Separan NP10 added and solution gently agitated. Solids completely settled in 3 minutes, 40 seconds.

without adding equipment!

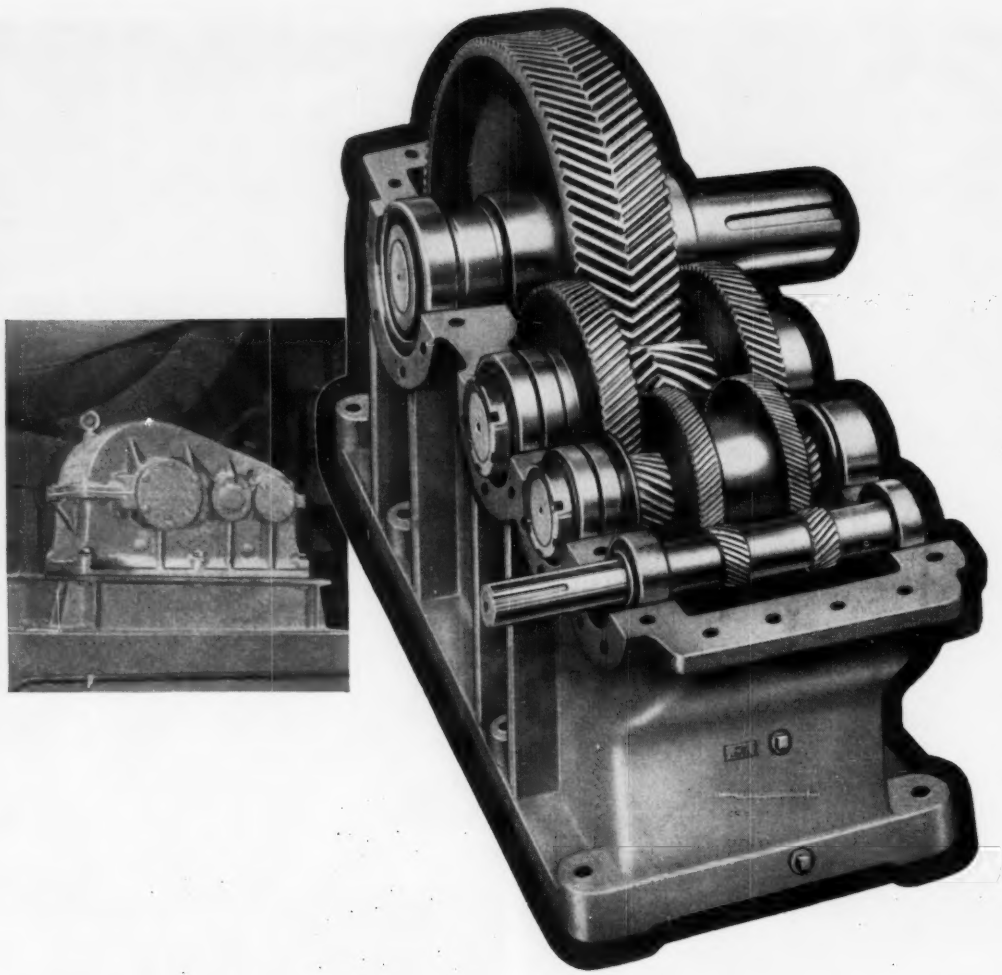
Separan NP10 (improved form of Separan 2610) offers greater clarity, higher purity and easier dispersibility!

Increased production in most types of water processing operations can be accomplished with a Separan flocculant—without extra capital investment!

REPORTS OF SUCCESSFUL USE OF SEPARAN NP10 IN PROCESS WATER TREATMENT

Location	Water Source	Separan NP10 Used	Results
East	river	½ ppm added last to chemical mix & coagulation tank	Improved clarity, reduced color, increased capacity
Ontario	river, high in clay	½ ppm added to clarifier, alum added in preceding tank	Improved clarity, reduced alum, elimination of silica
Far West	river, low in suspended & dissolved solids	0.1 ppm added after clarifier just before filters	Improved clarity & filter operation, elimination of silica
Southwest	brine, high in Ca.	0.15 ppm added to secondary mixing zone of clarifier	Improved clarity, increased throughput, reduced lime & $Fe_2(SO_4)_3$
Midwest	well water, hard	¼ ppm added to softener, lime and $NaAlO_2$ added in preceding tank	Reduced turbidity, less $NaAlO_2$, more stable against post-precipitation of $CaCO_3$
Southeast	river water, colored, turbid	¼ ppm added to clarifier, alum & lime added in preceding tank	Improved clarity, reduced color

YOU CAN DEPEND ON DOW



THE HEAVIER THE LOAD . . . THE MORE YOU NEED

PHILADELPHIA HERRINGBONE REDUCERS

Heavy repeated shock loads . . . high horsepower . . . round-the-clock operation . . . put them together and you have the kind of a job where Philadelphia Herringbone Reducers perform best. They will last longer and save your maintenance dollars because extra strength is built into every part . . . housings, shafting, bearings and gearing.

To be specific:

Housings are specially reinforced at points of greatest stress. Extra heavy bearings take shocks and heavy overhung loads in stride. Result: shaft alignment is accurate . . . and it stays accurate. Gears, pinions and bearings last longer.

To meet the specific needs of each application, gearing is specially designed and symmetrically arranged in the housing. Result: the bearings on each shaft carry equal loads, shaft deflections are minimized, bearings and gearing have higher shock load capacity.

Pound for pound, horsepower for horsepower and dollar for dollar, you can't buy a herringbone reducer that will outlast a Philadelphia. They are designed with *your* heavy duty drive problems in mind . . . so that you will never have a drive problem.

Philadelphia Herringbone Reducers are available in single, double and triple reduction for ratios of 1.75:1 to 292:1. Write today for your copy of Catalog H-55.

PHILADELPHIA GEAR CORPORATION

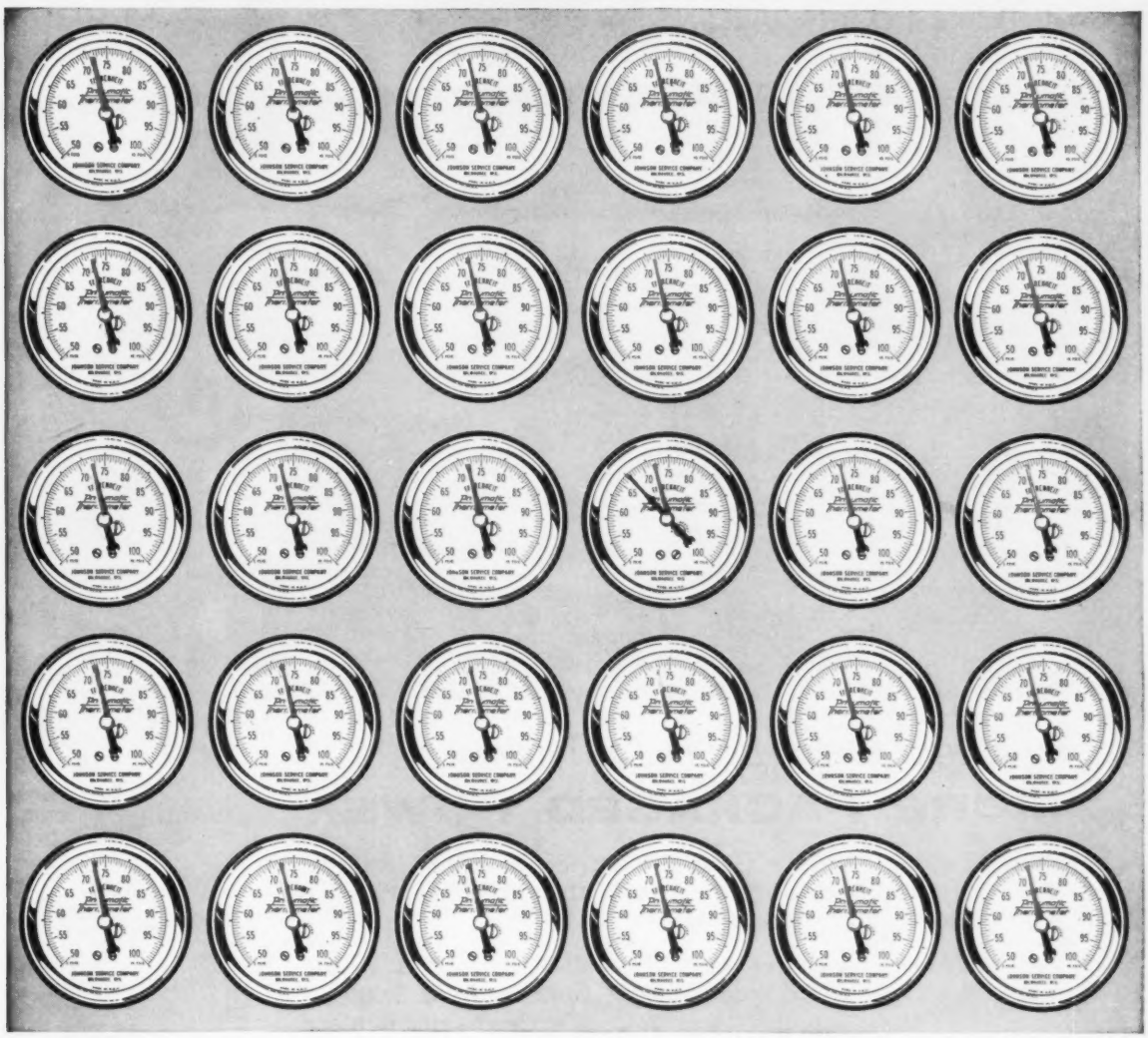
Erie Avenue and G Street • Philadelphia 34, Pennsylvania

philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

TRY THIS 2-SECOND SCANNING TEST!



SEE HOW FAST YOU FIND THE "TROUBLE" SPOT

You spotted it instantly, of course . . . and thereby demonstrated to yourself how pneumatic controls save important operational time and dollars in operating modern air conditioning and heating systems. If your visual perception is average, one glance revealed the "trouble" is in the middle row, third dial from right.

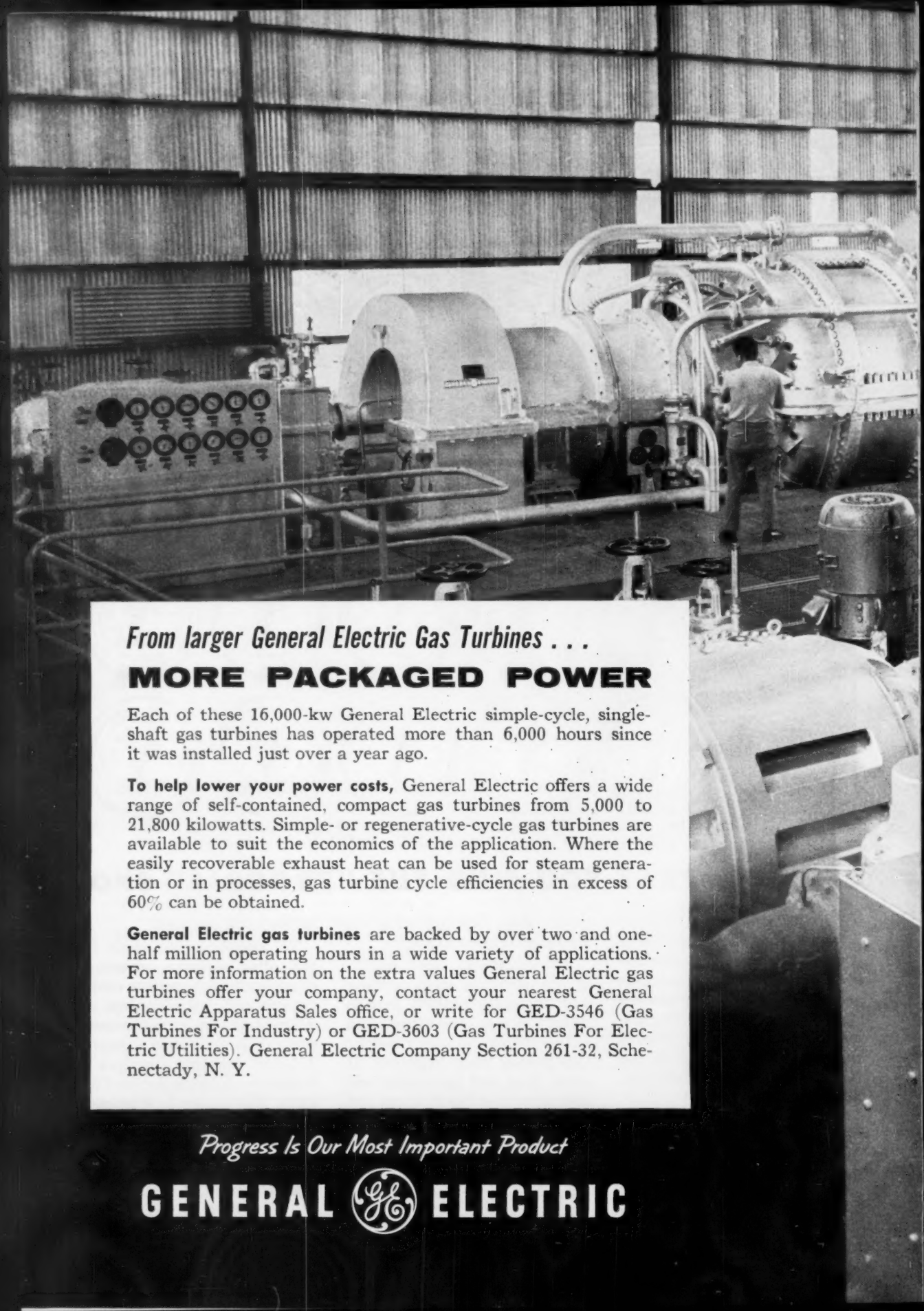
Similarly, from a Johnson Pneumatic Control Center, the operator can scan his panel and check key temperatures, pressures and other data from up to a hundred or more strategic control points in the building—*all in less time than it takes to tell it!*

The continuous visual display of vital operating data, exclusive with pneumatic controls, permits instant, remote observation of an entire system, allows constant supervision when required. It saves time and manpower and adds greatly to the economy and efficiency of operating any air conditioning or heating system. With pneumatic indication, there are no buttons to push, no waiting for periodic logging, no codes to check. *And no complex equipment to study and maintain!*

For complete facts about this and other exclusive advantages of pneumatic temperature control systems and control centers, call Johnson, the leader in pneumatic control. A talk with a nearby Johnson engineer involves no obligation. Johnson Service Company, Milwaukee 1, Wisconsin. Direct Branch Offices in Principal Cities.

JOHNSON CONTROL
PNEUMATIC SYSTEMS

DESIGN • MANUFACTURE • INSTALLATION • SINCE 1885



From larger General Electric Gas Turbines . . .

MORE PACKAGED POWER

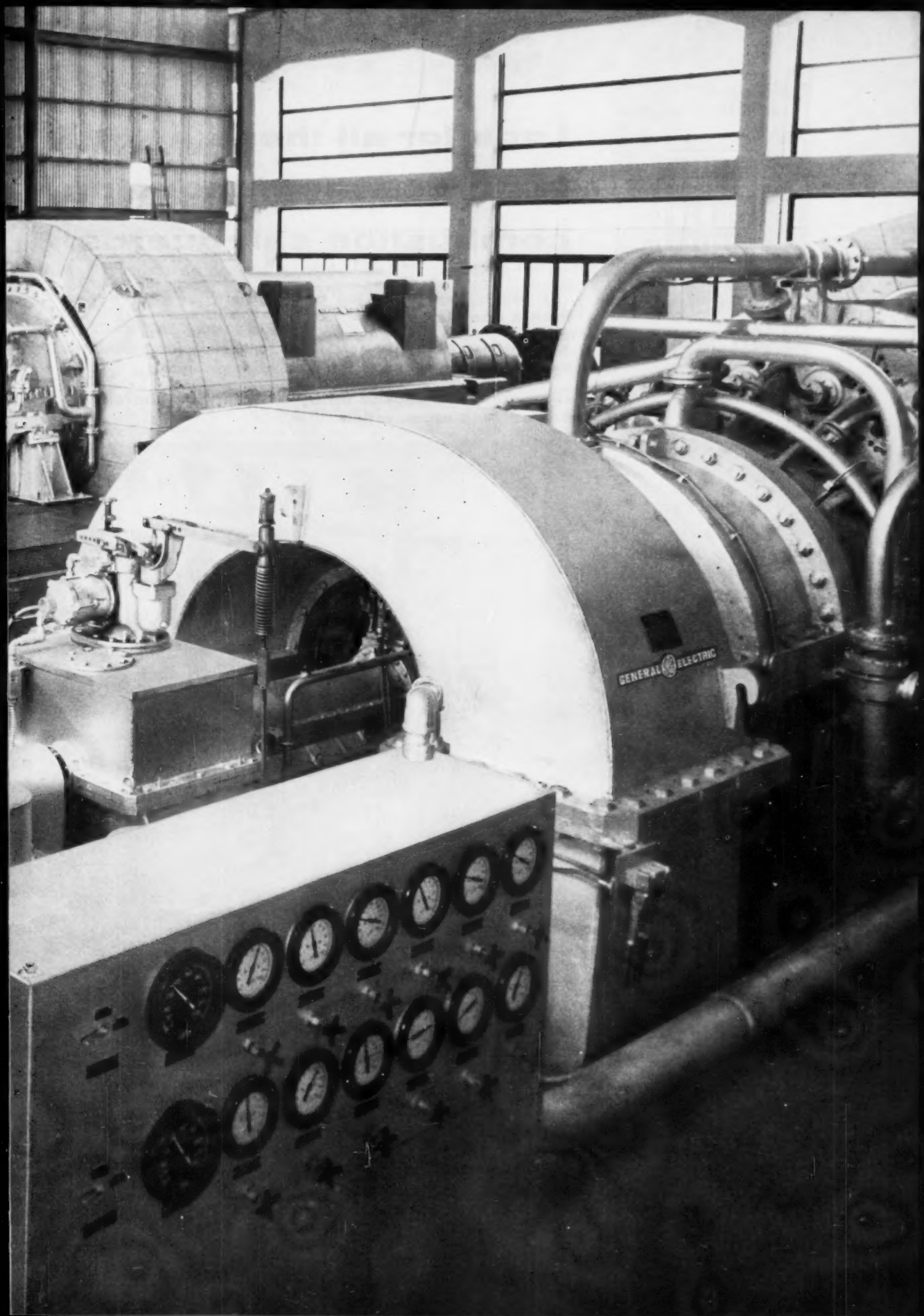
Each of these 16,000-kw General Electric simple-cycle, single-shaft gas turbines has operated more than 6,000 hours since it was installed just over a year ago.

To help lower your power costs, General Electric offers a wide range of self-contained, compact gas turbines from 5,000 to 21,800 kilowatts. Simple- or regenerative-cycle gas turbines are available to suit the economics of the application. Where the easily recoverable exhaust heat can be used for steam generation or in processes, gas turbine cycle efficiencies in excess of 60% can be obtained.

General Electric gas turbines are backed by over two and one-half million operating hours in a wide variety of applications. For more information on the extra values General Electric gas turbines offer your company, contact your nearest General Electric Apparatus Sales office, or write for GED-3546 (Gas Turbines For Industry) or GED-3603 (Gas Turbines For Electric Utilities). General Electric Company Section 261-32, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC


GENERAL ELECTRIC

THE MARK OF QUALITY

BARBER COLMAN

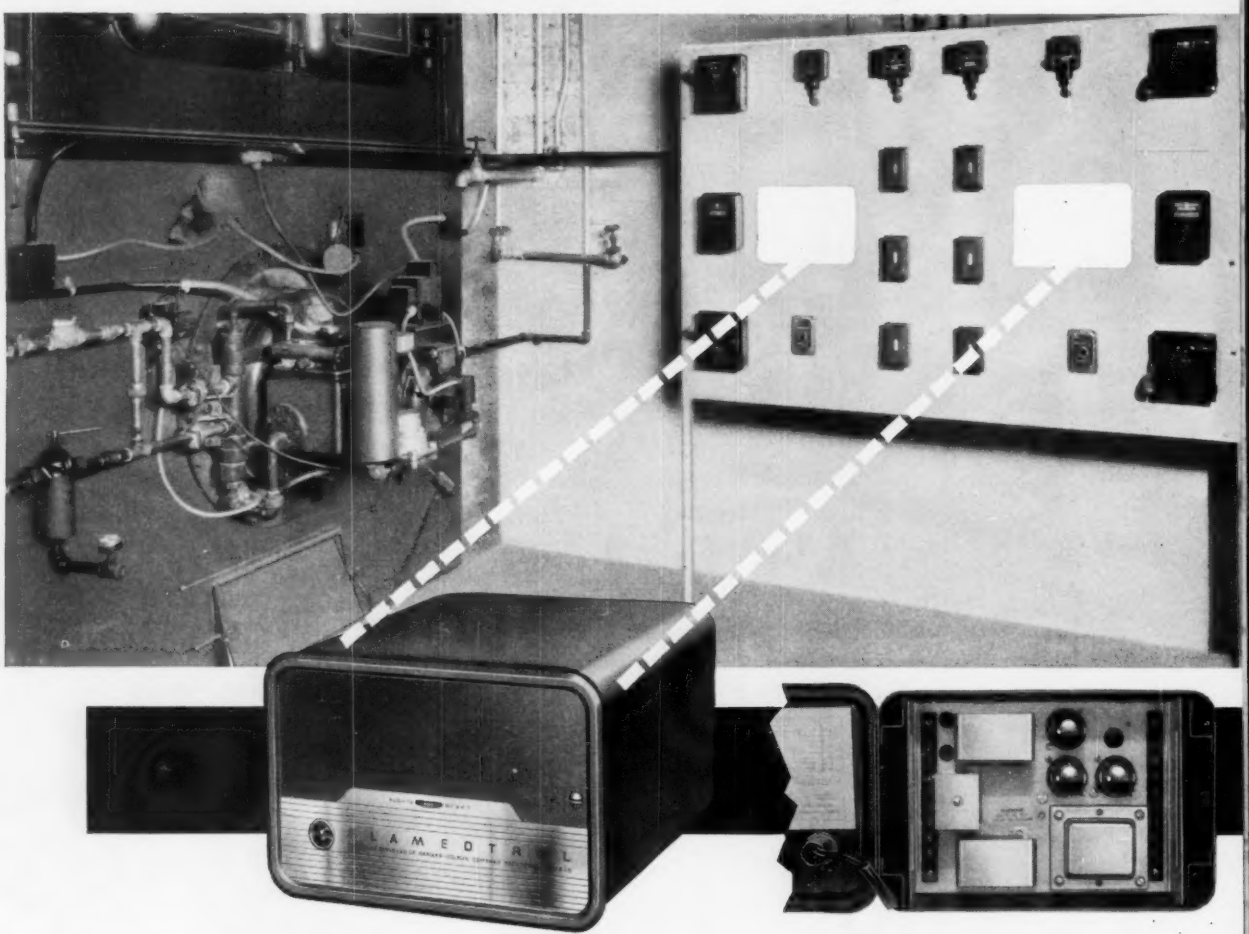
Wheelco Instruments

Look for all these features when choosing combustion safeguards

1. Ability to choose the best system for your needs from a complete line

2. Modern equipment designs to insure long trouble-free life, simple inspection and maintenance

3. Equipment backed up by a nationwide, thoroughly trained field organization



Pushbutton-start Flame-otrols, like the one shown here, are available with a Series 1470 Conductivity-Rectification system or a Series 1570 Infra-Red system.

Convenient external test points for checking circuits and voltages with conventional test instruments. Electronic tubes are standard types simplifying replacement.

write for literature describing Wheelco Flame-otrols

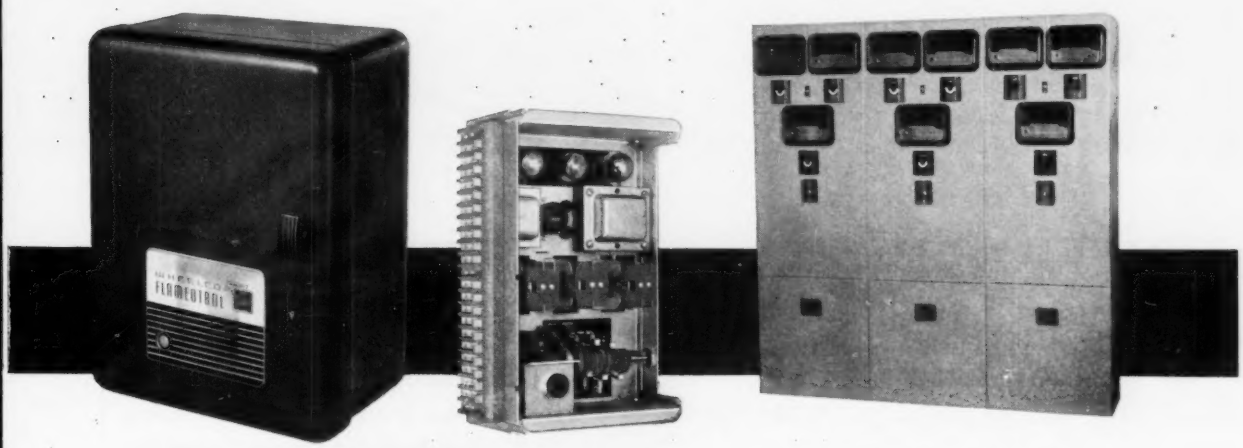
Unless your combustion safeguard system provides all these features you may be making an expensive and needless sacrifice. Wheelco Flame-otrols meet all these requirements whether the application be on a boiler, furnace, kiln, or dryer, and provide them at the cost of conventional equipment.

One Is Best — Wheelco offers two automatic operation and two pushbutton-start Flame-otrols to provide the exact system and the degree of control needed for a particular installation. Either Conductivity-Rectification "CR" systems or Infra-Red "IR" systems are used to monitor the flame. IR systems use a lead sulphide photoconductive cell as the sensing element, while CR systems use flame rods and emissive-type photo cells.

Easy Maintenance — With Wheelco's justly famous plug-in design, inspection and maintenance are easier and faster. The entire chassis may be removed for examination, adjustment, or repair. Standard electronic tubes are used throughout simplifying replacement from local stocks and cutting inventory needs. Wheelco's practical design permits Flame-otrols to be installed in every type of plant location by housing them in rugged, industrial-type steel cabinets provided with a gasketed, dust-tight, swing-out cover.

Control Centers Too — Custom-engineered installations that house a complete combustion safeguard system including Flame-otrols, pilot lights, alarms, etc., have long been a Wheelco specialty. These attractive centralized packages reduce installation costs and time, yet are provided with removable sections that offer flexibility for changing requirements.

Field Engineering Help — It pays to bring the Wheelco field engineer in on your planning when combustion safeguards are needed for a new or modernized installation. His experience plus the availability of a full line of instruments is your assurance of getting the system best suited to your needs. Wheelco field engineers are located in all principal cities, are as close to you as your telephone. This nationwide network, plus specialists in the home office, is always available to help you with your problems.



External and internal views of super-duty automatic Flame-otrols. Programing of these units includes purging, warm-up proving, pilot proving, low-fire stabilization, ignition timing and post-purging.

Custom-engineered Wheelco control centers can incorporate a wide variety of features. Either pushbutton-start or automatic Flame-otrols can be provided.

BARBER-COLMAN COMPANY

Dept. L, 1551 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. L, Toronto

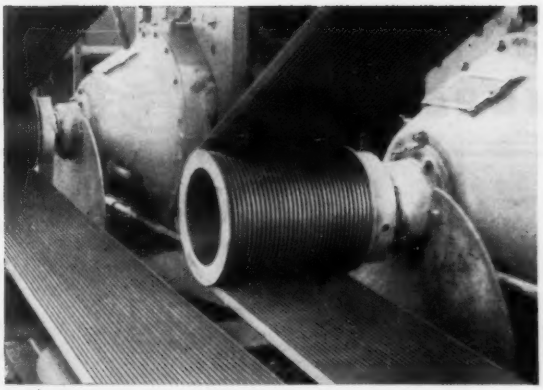
Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Electrical Components
Small Motors • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

WHY BUY ONLY 2/3 OF A CONVEYOR BELT?

IT'S THE *LAST THIRD* OF R/M CONVEYOR BELT LIFE That Gives "MORE USE *for Your* DOLLAR"

The last one-third of conveyor belt life determines its final cost. And now, R/M's *new* construction concept assures you ⅓ longer life with Ray-Man Conveyor Belt! Every belt feature—troughability, resiliency, fastener holding ability, strength member fabric, cover thickness and toughness—all contribute to your conveyor belt life and cost. Therefore every Ray-Man component is now *precision proportioned* to assure a degree of belt balance never before possible. It adds up to ⅓ longer belt service life . . . *lower* costs for your coal handling operations.

Let an R/M representative show you how *extra* life in the last ⅓ of conveyor belt service means "More Use per Dollar" with Ray-Man Conveyor Belt and other R/M heavy duty constructions. Write for Conveyor Belt Catalog 25CB.



R/M POLY-V® DRIVE

Patented new drive concept delivers up to 50% more power in same space as conventional multiple V-belt drives . . . or equal power in as little as ⅔ the space! Eliminates multiple V-belt "length matching" problems. Poly-V* assures more constant speed ratios, smoother running drive, longer drive life. Single unit belt permits narrower sheaves, less shaft overhang, less drive weight. Write for Bulletin #6638.

**Poly-V is a registered Raybestos-Manhattan trademark.*

CONDOR V-BELTS

"The smoothest running V-belts made" for general service. Balanced construction and straight sidewall design assure *more* grip, *less* slip . . . *longer* trouble-free performance at *lower* cost. For shock loads under rugged drive conditions, R/M Super-Power V-Belts give up to 40% greater hp capacity compared to standard types. Write for Bulletins.

RAY-MAN CONVEYOR BELT

Trains Naturally

Holds Fasteners

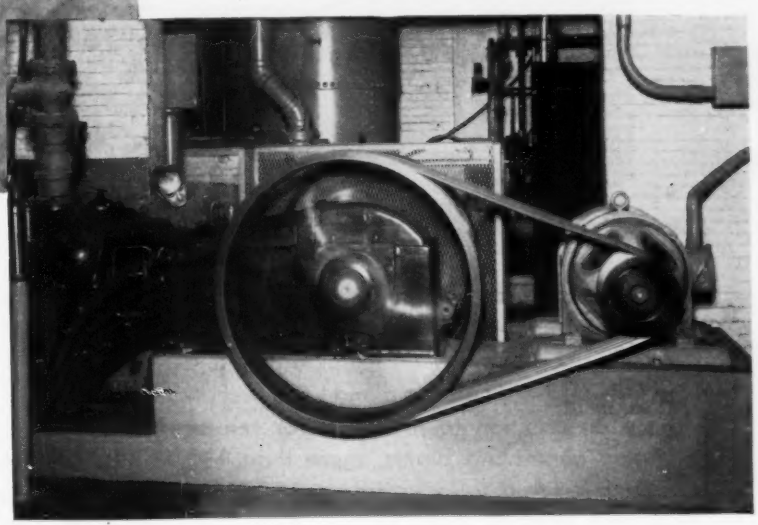
Resists Impact and Ripping

Requires No Breaker Ply

Double Compensation Relieves Outer-Ply Stress

Exclusive "XDC" Long-Wear Cover

Moisture Resistant, Mildew-Proof



BELTS • HOSE • ROLL COVERINGS • TANK LININGS • INDUSTRIAL RUBBER SPECIALTIES

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

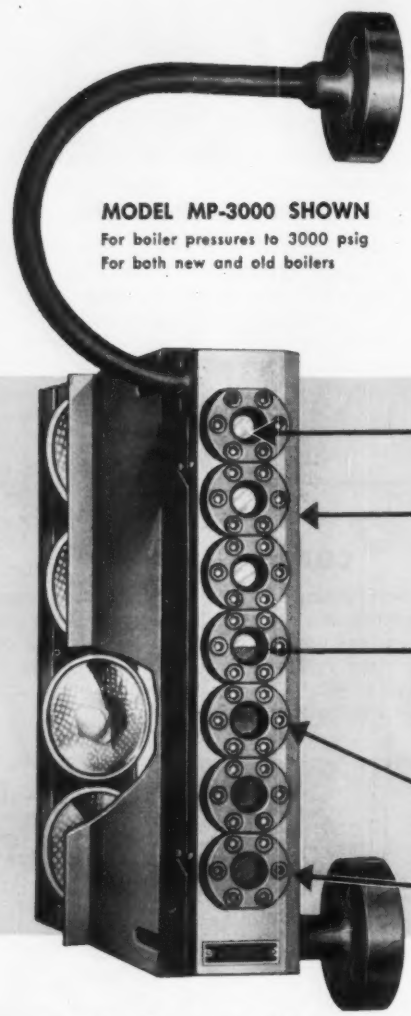
RAYBESTOS-MANHATTAN, INC.

Other R/M products: Abrasive and Diamond Wheels • Brake Blocks and Linings • Clutch Facings • Asbestos Textiles • Mechanical Packings • Engineered Plastics • Sintered Metal Products • Industrial Adhesives • Laundry Pads and Covers • Bowling Balls

MORE THAN ~~950~~ ~~1400~~ 2000

DIAMOND MULTI-PORT GAUGES

In use and on order for over ~~240~~ ~~300~~ 315 Central Station Generating Plants



MODEL MP-3000 SHOWN
For boiler pressures to 3000 psig
For both new and old boilers

- SMALL ROUND PORTS INSTEAD OF LONG GLASS AND MICA STRIPS
- GAUGE NEVER REMOVED FROM BOILER FOR GASKET CHANGES OR OTHER NORMAL MAINTENANCE
- STEAM SHOWS RED
- WATER SHOWS GREEN
- COMPLETE PORT CHANGE REQUIRES ONLY ABOUT 15 MINUTES
- EACH PORT THERMALLY INDEPENDENT

Also available is Model MP-900 for boiler pressures to 900 psig

Because the Diamond Multi-Port solves the problems inherent in water level gauges on boilers operating at high temperatures and pressures, it has had rapid and wide acceptance. In addition to the 2000 for central station generating plants, more than 185 have been sold to industrial power plants.

Advantages of the Multi-Port are many. In addition to those shown above, it has maximum thermal stability for rapid starting . . . "Hi-Lite" illuminator for improved readability . . . welded construction for permanent tightness . . . end stems can be furnished instead of flanges . . . startling reductions in maintenance costs.

Write for Bulletin 1174 (Model MP-3000) or Bulletin 2044 (Model MP-900) for more information.

8032

Diamond

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO • DIAMOND SPECIALTY LIMITED — *Windsor, Ontario*

LOUIS N ROWLEY, EDITOR • DECEMBER 1958 • ESTABLISHED 1882 Power

Clear thinking on the atom

In his blunt and colorful way, Ted Baumeister recently put his finger on a number of key aspects of nuclear development.* And, as usual, his views reflected a tough-minded unwillingness to allow the promise and glamor of the atom to stampede him into an irrational position.

As a first step toward clear thinking in this area, he stressed the need for understanding the numerous conflicting objectives that prevail among proponents of various nuclear programs. Closely akin to this is the need for hard-headed appraisal of the values of nuclear energy in its several fields of application. From such beginnings, and only from such beginnings, is it possible to arrive at sound judgments on specific lines of development.

I was particularly interested in his comments on the often-heard pleas for wholesale design and construction of nuclear-electric central stations. Proponents of such an acceleration of activity, overlook, he pointed out, the present lack of agreement as to the kind of reactor that should be built and the problems of the cost of such a speed-up in reactor building.

Here I find myself in agreement, particularly since we in the United States are fortunate in being free from the necessity of producing nuclear kilowatt-hours to offset imminent deficiencies in power supply from conventional sources. This situation, different from that in many other parts of the world, gives us the time to seek solutions that will yield the best long-run results.

The nuclear power field literally bristles with questions for which we have as yet but limited answers and, in many cases, only educated guesses. We have not yet tested fully even the most promising of reactor types thus far proposed, and interesting new concepts still keep coming along. The whole question of nuclear fuel cycles—natural vs enriched, solid vs mobile, conversion and breeding, reprocessing and waste disposal—needs vastly more exploration than we have yet been able to give it. These are just two of many areas crying for more investigation.

It can be argued that some of the problems could be solved by concentration on one or two designs in an enlarged construction program that would give quick experience on a commercial scale. But many of the fundamental questions could not be answered except by a broad program of experiment, such as we now have. Nothing could be more risky, it seems to me, than even an approach to "freezing" of designs when there is no compelling need to do so.

Rich in talent and resources as the United States may be, there is still a finite limit to the manpower and money we can devote to this area of technology. We should, I believe, use these resources to the full in a broad development program aimed at developing the best and most economical designs for the day when we *need* nuclear-generated energy. To the extent that we siphon off resources to build nuclear plants now, just for the sake of having them, we will dilute our effort and run a serious risk of delaying achievement of our true long-range goal.

*"Atomic Power and Solid Fuels," presented at Solid Fuels Conference, AIME and ASME, Old Point Comfort, Va., by Theodore Baumeister, Consulting Engineer, General Public Utilities Corporation; Stevens Professor of Mechanical Engineering, Columbia University.

When a motor we installed single phased, — Fusetron Fuses saved our reputation and a $200 rewind job

C. B. Meldrum, OWNER
MELDRUM ELECTRIC COMPANY
HOUSTON, TEXAS

Mr. Meldrum continues:

"Recently I sent several of my men to install a 50 h. p. air conditioning unit for a customer.

"It seems that my man who wired the 200 amp. switch failed to tighten a lug. He just hung the wire on the lug and then forgot to tighten it.

"When the unit was started, it didn't take long for trouble to develop. The loose connection caused one Fusetron fuse to blow. The motor started to run single phased but before any damage could result the other Fusetron fuses protecting the motor also blew and shut down the motor.

"My company stands behind its work. If the motor would have burned up, we would have rewound it without question. I know this would have cost us at least $200.

"What is important too, our reputation was saved and we have a satisfied customer. If the Fusetron fuses had not given us an opportunity to go back and do the job right before the motor was damaged, we would have been in a 'hot' spot."

For safe, modern, money-saving protection install FUSETRON dual-element FUSES and BUSS Hi-Cap FUSES throughout entire Electrical System!

Why Fusetron Fuses Provide Safest, Simplest Way to Prevent Damage from Single Phasing

When single phasing occurs, the current in the remaining phase increases about 100%. (Theoretically 73% but change in efficiency and power factor makes it about 100%.

This 100% overload on Fusetron fuses of motor-running protection size opens them and shuts down the motor.

Such dependable protection against motor burnouts from single phasing has never before been available.

You too, Can Get Safer, More Dependable and Money-Saving Protection with Fusetron Fuses

FUSETRON dual-element fuses provide 10 point protection against electrical troubles. This is unlike circuit breakers or ordinary fuses which, except in rare cases, protect only against short-circuits.

In Addition: Fusetron Fuses Require No Maintenance or Recalibration

They are calibrated at the factory by engineers. Once properly installed, they require no inspection or down-time necessary on mechanically operated devices. There are no hinges, pivots or contacts to stick or get out of order. Dust, corrosion or oxidation cannot increase a Fusetron fuse's capacity or lengthen its blowing time.

After years of inactivity, a Fusetron fuse will give the same safe, dependable protection if called upon to open as it would have on the day it was installed.

For Loads above 600 and up to 5,000 amps . . . Use BUSS Hi-Cap Fuses

They have an interrupting capacity sufficient to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

for more information, write for . . . **Bulletin FIS on Fusetron fuses**
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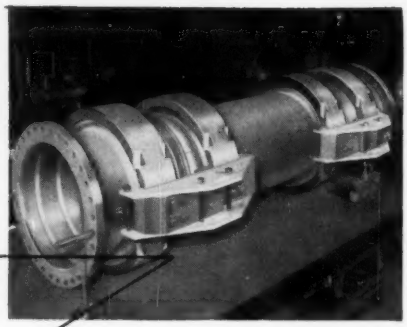
ALL IN A DAY'S WORK at *Pittsburgh Piping*

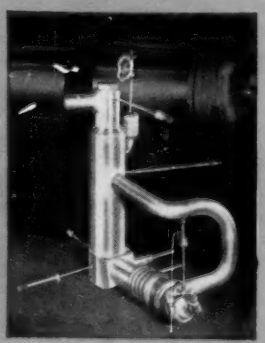


Every Pittsburgh Piping job is different, but all are alike in one respect . . . to control the flow and harness the energy of high temperature steam, gases, or liquids at high pressures. It's all in a day's work at Pittsburgh Piping to fabricate piping for a central station, an atomic energy installation, or for industrial and processing operations. Our service includes every phase from blueprint through erection: engineering, metallurgical control, pipe bending, machining, welding, heat treating, inspection, and testing. Use these facilities on your high temperature, high pressure piping jobs.

this BIG 10-TON EXPANSION JOINT

36" carbon steel joint, weighing ten tons, for cross-over piping in central station.

and this small PRESSURE RISER CONDENSER



Pressure riser condenser, fabricated of Stainless Steel Type 347; 2 feet high; wall thickness equivalent to 4" Schedule 160S. Stainless steel pressure vessel, for atomic energy application, appears in background.

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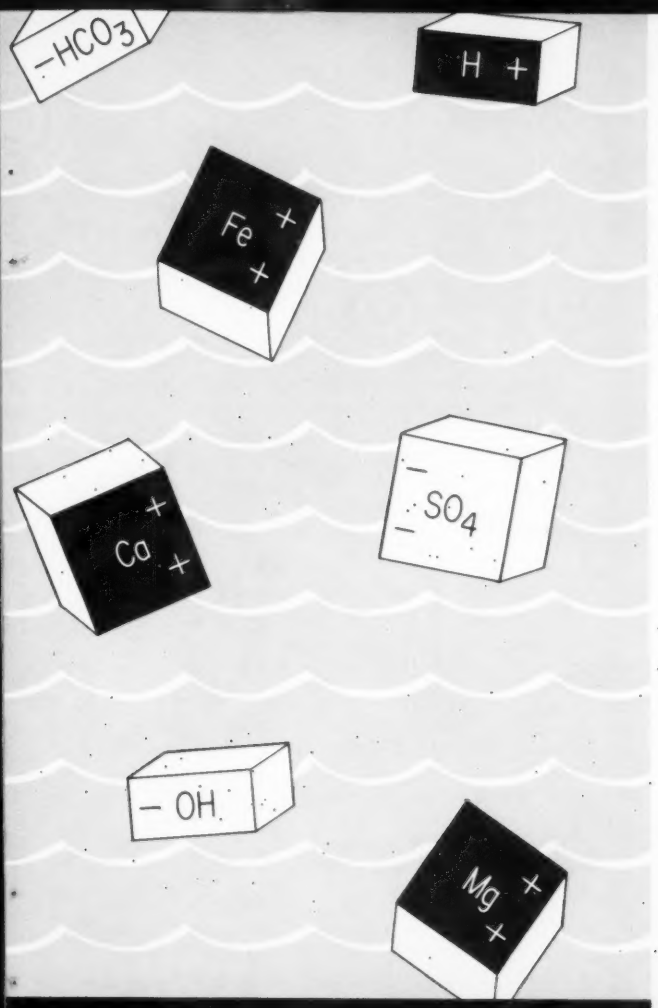

PART ONE

Water Treatment

By R H MARKS, Assistant Editor

Water is one of our most important raw materials. Industry uses a daily average of about 111 billion gallons. Irrigation takes 110 billion gallons a day. And over 19 billion gallons are distributed daily through municipal and rural water-supply systems. This adds up to an impressive daily total of 240 billion gallons. Demand for water is climbing so fast that experts predict a total use of 450 billion gallons a day by 1975.

Fortunately average daily runoff is about 1164 billion gallons. And not all water withdrawn from well, river or lake is consumed completely. About 90% of the water taken for public supplies and 98% of that used by industry is available for reuse in the same general area. This water is a valuable raw material even though much of it is contaminated with human or process wastes.

Looking at water this way, you arrive at a total daily consumption of only 87 billion gallons. So an overall water shortage doesn't look like a problem for the immediate future, although some areas will have more water than they need and others will have to cope with a short supply.

But it's clear that development of better ways to store, transport, conserve, recondition and reuse water will be economically justified. Since all of this water is a potential troublemaker unless made to behave, water treatment will take on ever-increasing importance.

First section of this 2-part report leads off with a look at water impurities and treatment aims, follows with data on basic water chemistry and concludes by scrutinizing today's water-treating chemicals and equipment.

In order to make this report easy to follow, we've carefully organized it into logical sections. Index, left, shows the structure.

Second part, in an upcoming issue, will show how the basic water-treatment tools are put to work to fashion economical treatment systems for boiler feed, cooling, process and other plant water services.

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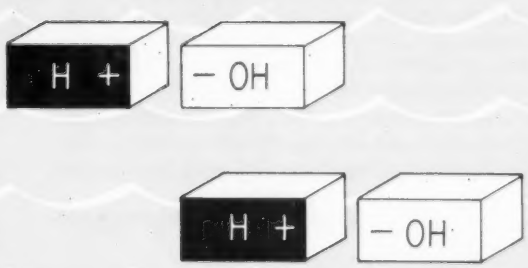


a **Power** special report

December 1958

What water quality does your plant really need?

First reaction of many engineers to this question is "Pure water, of course!" But translating an answer like that into action often means a lot of needless expense in installing and operating a complex water-treating system. "Pure" or high-quality water is practical only for high-pressure power plants, nuclear power reactors and certain process waters. Generally water that is tailored for each job with a specific end result in mind is less costly, easier to obtain and completely satisfactory.

If water were H_2O and nothing else, or if all waters carried the same impurities, treatment could be boiled down to a nearly uniform prescription for each use. But pure water never occurs in nature and impurities vary considerably. Closest natural approach to "pure" water is rain. But even rain contains enough dissolved oxygen and CO_2 to make it corrosive.

Impurities in natural waters depend largely on the source. Wells and springs are classed as ground waters; rivers, lakes as surface waters.

Ground water picks up impurities as it seeps through the rock strata, dissolving some part of almost everything it contacts. But the natural filtering effect of rock and sand usually keep the water free and clear of suspended matter.

Surface waters often contain (1) organic matter such as leaf mold and (2) insoluble suspended matter such as sand and silt. Pollution from industrial waste and sewage is frequently present. Stream velocity, amount of rainfall and where the rain occurs on the watershed can rapidly change the character of the water.

In general water tends to cause trouble in industry by (1) forming deposits that interfere with heat transfer or impair product quality and (2) damaging metals, wood or other materials of construction used to store, transport or otherwise contain water. So the broad aims of treatment are to prevent deposits and control corrosion. This must be done at a cost economically justified by benefits of trouble-free water.

All natural waters—even rain, snow,

Turbidity and sediment

Turbidity is suspended insoluble matter, including coarse particles (sediment) that settle rapidly on standing. Amounts range from almost zero in most ground waters and some surface supplies to 60,000 ppm in muddy and turbulent river water. Turbidity and sediment are objectionable for practically all uses. Standard for drinking water is 10 ppm max. High-grade pulp and paper calls for water containing not more than 5 ppm turbidity

Color

Surface waters from swampy areas often are highly colored from decaying vegetation. Amount of color is found by comparing its intensity with a standard. Color of 10 units isn't visible in a tumbler, but 20 units (drinking water maximum) are noticeable. Many processes can't stand more than 5 units. In the paper industry, color in process water stains the cellulose fibers, affects brightness or color of white or dyed papers

Microbiological growths

Various growths occur in surface water, seldom in uncontaminated deep wells. Microorganisms include diatoms, molds, bacterial slimes, algae, iron and manganese bacteria, sulfur or sulfate-reducing bacteria, etc. Some are dangerous to health; others cause bad taste and odors or produce clogging deposits. Although many of these organisms are nonpathogenic, water can't be assumed safe simply because it is clear and odorless

Fluoride

Amount rarely tops 4.0 ppm (average is much less than 1.0 ppm). There's evidence that a small amount prevents tooth decay. United States Public Health Service sets 1.5 ppm as the maximum for drinking water

Water impurities will vary with the source of supply

Aside from drinking and sanitary purposes, the five main uses of water in industry are: (1) generating steam to produce power in utilities and industrial plants (2) heating and cooling (3) transporting and processing materials such as pulp and paper (4) as a raw material that becomes part of a finished product such as canned foods and beverages (5) passing along domestic and industrial wastes.

Sometimes water can be used without treatment. But more often it contains impurities that must be removed,

sleet and hail—and all treated municipal supplies contain some of these impurities

Hardness

Water's content of soluble calcium and magnesium salts equals hardness, expressed as calcium carbonate equivalents in gr per gal or ppm. These salts, in order of their relative average abundance in water, are (1) bicarbonates (2) sulfates (3) chlorides (4) nitrates. Calcium salts are about twice the concentration of magnesium salts. Carbonate (temporary or bicarbonate) hardness is that present as bicarbonate salts. Noncarbonate (permanent) hardness equals the remainder present as sulfates, chlorides and nitrates. Hardness is undesirable because heating or evaporating produces hard stony scale deposits that clog fluid systems, cause damage

Mineral acidity

Surface waters contaminated with mine drainage or trade wastes will contain sulfuric acid, plus ferrous, aluminum and manganous sulfates. They're corrosive and unfit to use

Silica

Most natural waters contain silica ranging from 1 to over 100 ppm. It forms hard scale in h-p boilers, passes over with steam to form glassy deposits on turbine blades

Sodium and potassium salts

Extremely soluble, they don't deposit unless highly concentrated. They'll prove troublesome if distilled-water quality is needed

Hydrogen sulfide

This dissolved gas gives a rotten-egg odor to sulfur waters making them distasteful, corrosive to most metals. Waters with more than 1 ppm are definitely undesirable

Iron

Most common soluble iron in ground waters is ferrous bicarbonate. Water is clear and colorless when drawn but, on exposure to air, clouds up and deposits a yellowish or reddish-brown sediment of ferric hydroxide that stains everything it contacts. Although majority of iron-bearing waters have less than 5 ppm, as little as 0.3 ppm can give trouble

Manganese

Rarer than iron in water, manganese occurs in similar forms and is troublesome in industrial and municipal supplies. Pipeline deposits form rapidly with as little as 0.2 ppm

Carbon dioxide

Free carbon dioxide is found in most natural supplies. Surface waters have the least although some rivers contain to 50 ppm. In ground waters it varies from zero to concentrations so high that carbon dioxide bubbles out when pressure is released. Most well waters contain from 2 to 50 ppm. Carbon dioxide also forms when bicarbonates are destroyed by acids, coagulants, high temperatures. It's corrosive and accelerates oxygen corrosion

Methane

Occasionally enough methane is found in well waters to cause fire and explosion hazard. It's readily identified by its flammability

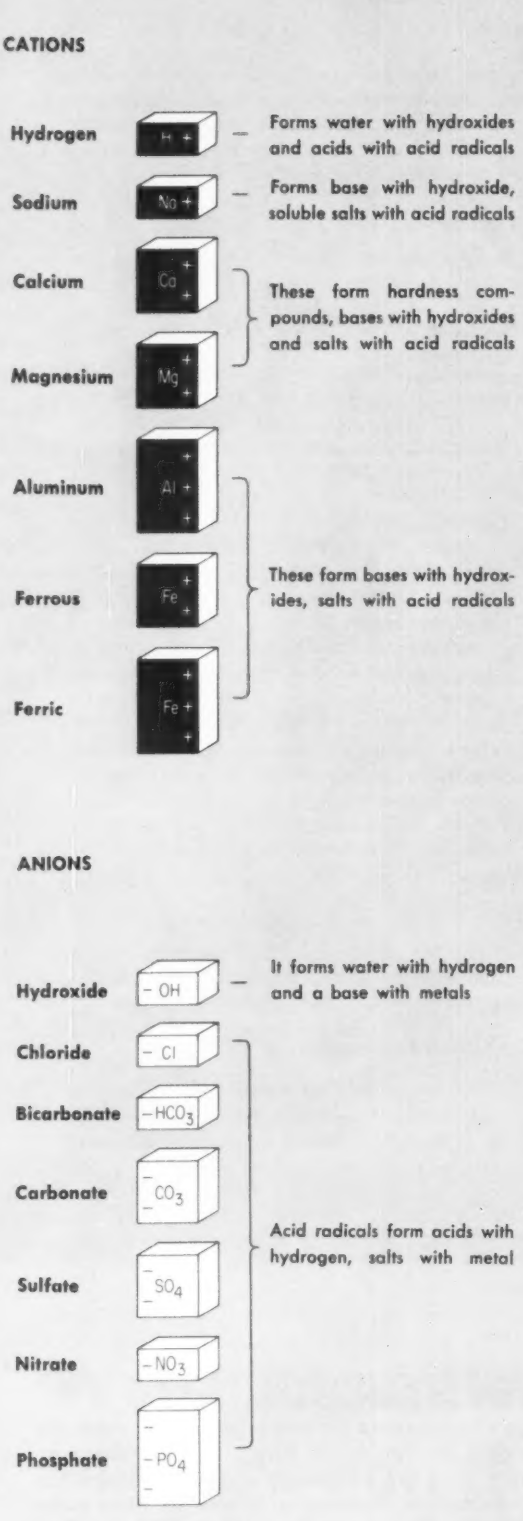
Oxygen and nitrogen

Both are found in surface and aerated waters; deep wells contain very little, if any. Nitrogen is an inert gas, while oxygen is corrosive to iron, zinc, brass and other metals

reduced or stabilized. First step in selecting treatment is a survey of available water supply and the uses to which water is put. If you have private wells, analyze separate samples from each. When it's from the surface, take a series of analyses over a period of time. Check records carefully to spot any changes in composition. If you use a municipal supply, check their records for maximum and minimum amounts of impurities over a period of years. Water from a deep well usually has a uniform composition. But it is a mistake to assume that water from a nearby well will have the same analysis.

Surface waters except for very large lakes or reservoirs vary greatly in composition during a year. Maximum impurities in rivers can range up to 400 times the minimum amounts. Hardness of Mississippi River water near Memphis, Tenn. varies from 108 to 184 ppm. Turbidity in large lakes and reservoirs also has a wide range. But soluble minerals often show little annual change.

Cations, anions are basic chemical units



ACTUAL COMPOUNDS of water chemistry can be constructed with chemical building blocks, *above*. Match any cation with any anion block. If their heights aren't the same, pile on duplicate blocks until both piles are equal

First working tool is basic knowledge of water chemistry

Chemical building blocks, left, are used here to represent those cations and anions important in water treatment. Table, facing page, lists properties of the important elements, acid radicals and acids. Atomic weight of each element is merely a way of comparing the weight of its atoms with that of the oxygen atom. For example, the oxygen atom weighs 16 times as much as a hydrogen atom. If the atomic weight of oxygen is 16, then hydrogen's must be 1 to maintain the relationship.

Atoms of elements contained in a chemical compound are bound together in definite patterns as molecules. Formula of a compound is the same as that of the molecule. For example, formula for water is H_2O. This means that each molecule of water contains two atoms of hydrogen and one atom of oxygen.

Molecular weights are easy to figure: just add the weight of atoms present in each molecule. Molecular weight of water then becomes $1 + 1 + 16$ or a total of 18. In the same way sulfuric acid has a molecular weight equal to the sum of atomic weights for two hydrogen atoms, one sulfur atom and four oxygen atoms. This amounts to a total of $1 + 1 + 32 + 4(16)$ or 98.

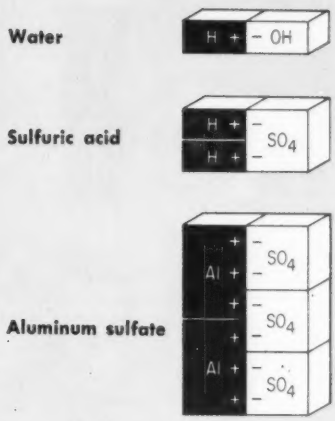
Acids used in inorganic water chemistry consist of hydrogen combined with an acid radical. So the SO_4 group in the molecule of sulfuric acid is called an acid radical. When these acids are brought in contact with other compounds, the resulting reaction brings about many regroupings. But, in most cases, the acid radical moves around as a unit. The four atoms of oxygen and one of sulfur stick together in moving to some new combination. So it's convenient to look on these acid radicals as a chemical-anion unit. In every case the acids listed in table, facing page, are a combination of hydrogen and one of the many acid radicals.

Valence of an acid radical or an element is a measure of its chemical combining power. Hydrogen is taken as the standard with a valence of one. Any atom or radical that combines with hydrogen on a one-to-one basis will also have a valence of one. Hydrochloric acid's formula, HCl, tells us that one atom of hydrogen combines with one atom of chlorine. Thus the valence of Cl is one.

Chloride anions can also combine with sodium cations to produce NaCl or common salt. Since chloride has a valence of one and it unites with one atom of sodium, the valence of sodium is also one. Formula for sulfuric acid is H_2SO_4. Hydrogen has a valence of one. But it takes two atoms of hydrogen to combine with one sulfate radical. This means that the sulfate radical has a valence of two.

Equivalent weight is the number of pounds combining with one pound of hydrogen. In other words it is the

Here's how blocks match up to show actual compounds



The dark cation of hydrogen matches evenly with the light hydroxide anion to give HOH, a graphic way of writing H_2O or water. When hydrogen combines with any of the acid radicals, result is an acid. One hydrogen atom paired with an atom of chlorine forms a matched molecule of HCl or hydrochloric acid. But when hydrogen is paired with sulfate, the sulfate block is twice as tall. Since matching is only complete when each pile is the same height, another atom of hydrogen is needed, as shown by chemical block diagram at left.

Formation of aluminum sulfate, left, calls for a matching combination of two aluminum atoms to three sulfate radicals. In all these groupings, plus signs of cation blocks are opposite minus signs on anion blocks. You can look on these as opposite charges of electricity binding cations to anions.

Number of plus or minus signs on a given block represents valence of that element or radical. Height of each block is proportional to this value. Thus these chemical building blocks graphically show the valence principle. For example, hydrogen has a valence of one, sulfate two and aluminum three.

Important elements, acid radicals and acids in water chemistry

Element	Symbol	Atomic weight	Valence	Equivalent weight
Aluminum	Al	27.0	3	9.0
Barium	Ba	137.4	2	68.70
Calcium	Ca	40.1	2	20.05
Carbon	C	12.0	Variable	——
Chlorine	Cl	35.46	Variable	35.46
Fluorine	F	19.0	1	19.0
Iron (ferrous)	Fe''	55.8	2	27.9
Iron (ferric)	Fe'''	55.8	3	18.6
Hydrogen	H	1.0	1	1.0
Magnesium	Mg	24.3	2	12.15
Nitrogen	N	14.0	Variable	——
Potassium	K	39.1	1	39.1
Oxygen	O	16.0	2	8.00
Phosphorus	P	31.02	Variable	——
Sodium	Na	23.0	1	23.0
Sulfur	S	32.0	Variable	——
Silicon	Si	28.06	4	14.03

Acid radicals	Formula	Molecular weight	Valence	Equivalent weight
Bicarbonate	HCO_3	61.0	1	61.0
Carbonate	CO_3	60.0	2	30.0
Chloride	Cl	35.46	1	35.46
Nitrate	NO_3	62.0	1	62.0
Hydroxide	OH	17.0	1	17.0
Phosphate	PO_4	95.0	3	31.66
Sulfite	SO_3	80.0	2	40.0
Sulfate	SO_4	96.06	2	48.03

Acid	Formula	Molecular weight	Equivalent weight
Carbonic acid	H_2CO_3	62.0	31.0
Hydrochloric acid	HCl	36.46	36.46
Phosphoric acid	H_3PO_4	98.0	32.67
Sulfuric acid	H_2SO_4	98.1	49.05
Sulfurous acid	H_2SO_3	82.1	41.05

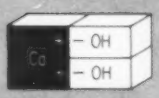
weight of substance that will contain a unit weight of hydrogen. For example, 98 grams of sulfuric acid contain two grams of hydrogen. So 49 grams of sulfuric acid are required to carry one gram of hydrogen. On this basis sulfuric acid has an equivalent weight of 49.

Chemical compounds can be formed by matching up cation and anion blocks. Dark cation blocks are metallic elements with exception of hydrogen. Ferric and ferrous blocks represent two different forms of iron. Light anion blocks are acid radicals with exception of hydroxide. Height of each block is proportional to its valence. But, of course, the relative size and shape of blocks don't indicate size or shape of atoms or molecules.

Actual compounds shown above are constructed with this technique. Aluminum sulfate molecule is a good example of the class of chemicals known as salts. These are formed by bringing together a metal and an acid radical.

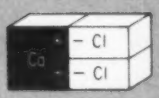
If we combine a metal cation with the hydroxide anion, we get what is known as a base. These react strongly with acids and are looked upon as their opposite number. Combining the metal sodium with hydroxide gives sodium hydroxide, a base that reacts strongly with acids.

Calcium compounds are found in raw water and added in treatment



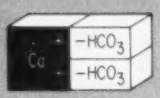
$Ca(OH)_2$

Calcium hydroxide
Used in lime-soda softeners



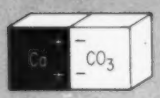
$CaCl_2$

Calcium chloride
Constituent of hardness



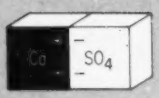
$Ca(HCO_3)_2$

Calcium bicarbonate
Heat drives off CO_2, precipitates calcium carbonate



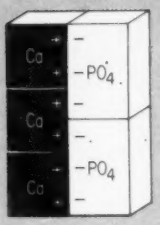
$CaCO_3$

Calcium carbonate
Forms sludge or soft scale



$CaSO_4$

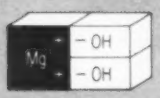
Calcium sulfate
Forms hard scale



$Ca_3(PO_4)_2$

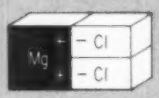
Tricalcium phosphate
Sludge formed by action of phosphates on calcium hardness

Magnesium compounds also have dual role as impurities and treatment chemicals



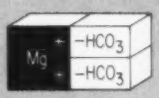
$Mg(OH)_2$

Magnesium hydroxide
Insoluble precipitate of lime-soda process



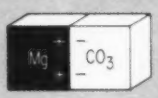
$MgCl_2$

Magnesium chloride
Soluble, corrosive, constituent of hardness



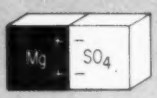
$Mg(HCO_3)_2$

Magnesium bicarbonate
Heat drives off CO_2 to form magnesium carbonate



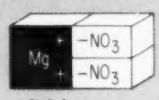
$MgCO_3$

Magnesium carbonate
Moderately insoluble



$MgSO_4$

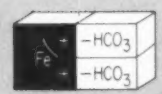
Magnesium sulfate
Soluble



$Mg(NO_3)_2$

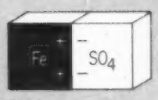
Magnesium nitrate
Soluble

Iron compounds . . .



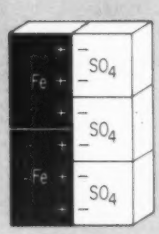
$Fe(HCO_3)_2$

Ferrous bicarbonate
Most common form of iron in water



$FeSO_4$

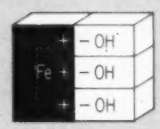
Ferrous sulfate
Common iron coagulant



$Fe_2(SO_4)_3$

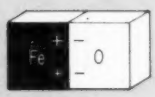
Ferric sulfate
Another iron coagulant

. . . find use as coagulants



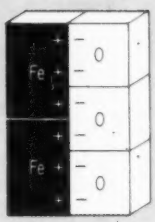
$Fe(OH)_3$

Ferric hydroxide
Floc produced by ferric or ferrous sulfate



FeO

Ferrous oxide
Product of iron corrosion



Fe_2O_3

Ferric oxide
Product of iron corrosion

Mating cation, anion building blocks help show structure of many common compounds

Compounds shown above include most of those commonly encountered in water treatment. Each group includes combinations of a single cation with various anions.

Except for water, all hydrogen compounds are acids. Carbonic acid is pictured as a bicarbonate and a carbonate of hydrogen. Probably the more correct presentation from a chemical standpoint is carbonate of hydrogen. In carbonic acid the building block of bicarbonate or carbonate is easily broken up. Heating to 212 F destroys the radical, drives off carbon dioxide and leaves plain water. Magnesium and calcium bicarbonate are also unstable when heated, giving up carbon dioxide.

Cold water absorbs carbon dioxide to produce carbonic acid. Ordinary soda water is nothing more than a strong solution of carbonic acid.

Most sodium compounds have the family characteristic of high solubility and are rarely scale forming. In addition to sodium compounds found in raw water, several are often products of treatment. Softening leaves a residual of sodium carbonate. Sodium sulfate appears as an end product when removing oxygen chemically from water with sodium sulfite.

At opposite extreme are the frequently insoluble and scale-forming compounds of calcium and magnesium. Fortunately, bicarbonates and sulfates of both calcium

Hydrogen compounds range all the way from water to sulfuric, phosphoric acids

H_2O
Water

HCl
Hydrochloric acid
May be added in treatment

H_2CO_3
Carbonic acid
Breaks down to H_2O and CO_2 when heated

H_2CO_3

H_2SO_4
Sulfuric acid
May be used in treatment

H_3PO_4
Phosphoric acid
May be used in treatment

Sodium compounds handle a variety of treatment jobs including oxygen removal

$NaOH$
Sodium hydroxide
May be used in treatment

$NaCl$
Sodium chloride
Used to regenerate cation exchangers

$NaHCO_3$
Sodium bicarbonate
Breaks down to sodium carbonate and CO_2 when heated

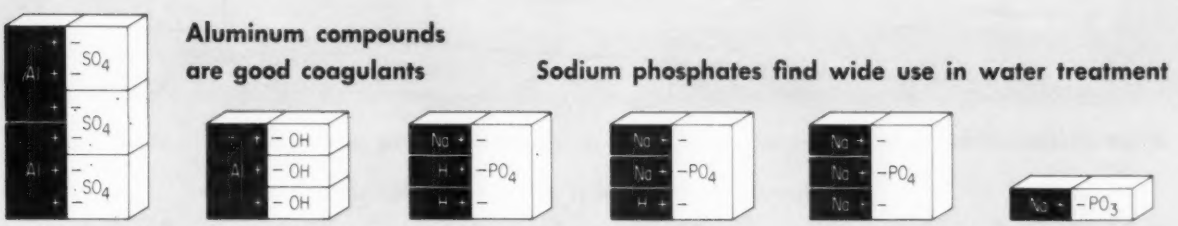
Na_2CO_3
Sodium carbonate
Under pressure and heat breaks down to caustic soda and CO_2

Na_2SO_3
Sodium sulfite
Chemically removes oxygen from water

Na_2SO_4
Sodium sulfate
Present in water, sometimes added; also a product of treatment

Aluminum compounds are good coagulants

Sodium phosphates find wide use in water treatment



$Al_2(SO_4)_3$
Aluminum sulfate
Coagulant

$Al(OH)_3$
Aluminum hydroxide
Dense floc made by coagulation

NaH_2PO_4
Monosodium phosphate

Na_2HPO_4
Disodium phosphate

Na_3PO_4
Trisodium phosphate

$NaPO_3$
Metasodium phosphate

and magnesium are soluble at room temperature. But when calcium bicarbonate is heated carbon dioxide is driven off, calcium carbonate comes down as insoluble sludge or deposits as a crystalline scale.

Four forms of sodium phosphate shown above are widely used in water treatment. Tricalcium phosphate is a fine precipitate produced by the reaction of calcium hardness and the phosphate compounds.

Iron has a valence of two in ferrous compounds and three in ferric compounds. In untreated water it often occurs as ferrous bicarbonate. Both ferric and ferrous sulfate find use as coagulants. With lime or caustic soda, ferric sulfate gives a dense floc of ferric hydroxide that helps remove all types of suspended matter from water. Ferrous and ferric oxide are corrosion products of iron.

Aluminum sulfate produces a dense aluminum hydroxide floc when it is added to the water for coagulation.

When two or more chemical compounds are brought together they often react mutually to produce new compounds. This is called a reaction and is shown by a chemical equation. On its left side are the original compounds. On the right are those remaining after the reaction. However, reactions also tend to work in reverse. Each compound is expressed by its formula.

In every chemical equation the left and right sides must balance atom for atom. Every atom present at the start must be accounted for at the end.

The building-block technique helps show these chemical reactions because the acid radicals usually go through unchanged. Most of the basic chemical reactions in water treatment can be pictured by merely shifting cation and anion building blocks. Chief exception is the case where bicarbonates and carbonates are destroyed by heating or aeration and as a result give off carbon dioxide.

REPORT OF WATER ANALYSIS

Date Collected 10/30/58
Source well
Date analyzed 11/4/58

Total dissolved mineral solids		ppm
Organic matter	none	ppm
Suspended solids	5	ppm
Chloroform, extractable (oil, etc)	none	ppm
pH	7.7	
Phenolphthalein alkalinity as $CaCO_3$	0	ppm
Methyl orange alkalinity as $CaCO_3$	205	ppm
Hydroxide alkalinity as $CaCO_3$	0	ppm
Hardness as $CaCO_3$	282	ppm
Specific conductance		micromhos

	Parts per million	Equivalents per million
Silica as SiO_2	5	
Iron as Fe_2O_3	1.2	
Calcium as Ca	62	
Magnesium as Mg	31	
Sodium and potassium as Na	38	
Bicarbonate as HCO_3	250	
Carbonate as CO_3	0	
Hydroxide as OH	0	
Chloride as Cl	11	
Sulfate as SO_4	138	
Nitrate as NO_3	0	
Carbon dioxide as CO_2	10	
Turbidity	5	

Physical characteristics of sample: Clear when drawn

WATER-ANALYSIS REPORT FORM gives complete information about the water sample including physical characteristics when collected

Now let's examine the water analysis

Analyzing a water sample is the process of finding out how much of the various impurities and other chemical substances are present in water.

Results are usually expressed in parts per million (ppm) and tabulated on a form like the one shown above. Parts per million is a measure of proportion by weight such as one pound in a million pounds. Grains per gallon (gpg) is another way of expressing the amount of a substance present. One gpg equals 17.1 ppm. Individual impurities with possible exception of hardness are rarely reported as gpg. However, quantities in ppm are often converted to gpg for convenience in calculating capacity of water-treating equipment.

Water usually contains a wide variety of dissolved compounds. Each compound breaks into its respective ions when dissolved. In other words, atoms of the combination molecule separate. Although chemists can measure amount of each cation and anion in the solution, it's impossible to chemically analyze amount of each individual compound. We can only assume that various ions recombine in certain ways upon evaporation or precipitation. Ionic weight of ions such as calcium, sodium, sulfate and chloride can be determined. But this doesn't tell us how much individual calcium sulfate, sodium sulfate or sodium chloride originally went into the solution.

Since analysis measures only ions, never compounds, it's logical to use the ionic form. Usually no attempt is made to indicate hypothetical compounds. If the analyses do show them, they are figured by a chemist from their ionic weights by using certain arbitrary assumptions.

The combined form of analysis is best described as a rule-of-thumb attempt to put a water-analysis report in to shape for practical interpretation. It has fallen almost completely out of use because the ionic form is more convenient, easier to interpret and understand.

By adding a column for ppm expressed as calcium carbonate or equivalents per million (epm), it's possible to reduce all ions present to a common denominator. This makes it easy to (1) calculate amounts of reacting chemicals (2) size equipment and (3) check accuracy of analysis.

Expressing an ion such as calcium in terms of its calcium carbonate equivalent is done easily by compar-

What is the meaning of pH in water chemistry?

Definition of pH is the logarithm of the reciprocal of hydrogen-ion concentration. It's also a number between 0 and 14 indicating degree of acidity or alkalinity. The pH scale resembles a thermometer or hydrometer scale. Just as a thermometer measures intensity of heat and a hydrometer the density of a solution, the pH scale indicates intensity of acidity or alkalinity.

Midpoint of the pH scale is 7 and a solution with this pH is neutral. Numbers below 7 denote acidity; those above alkalinity. Since pH is a logarithmic function, solutions having a pH of 6.0, 5.0 and 4.0 are 10, 100 and 1000 times more acid than one with pH of 7.0.

Now let's apply this to water chemistry. In addition to molecules of H_2O, pure water contains separated parts of molecules called hydrogen ions ($H+$) and hydroxyl ions ($OH-$). Amount of dissociation is constant at any given temperature. At 25 C the product of the $H+$ and $OH-$ concentrations is $1x10^{-14}$. When hydrogen-ion concentration changes, the hydroxyl-ion concentration changes in proportion and always in the opposite direction. If the $H+$ ions decrease, the $OH-$ ions increase enough so product of the two concentrations at 25 C remains $1x10^{-14}$. The exponent -14 is the basis of the pH scale, a method of expressing hydrogen-ion concentration in terms of a negative logarithm to the base 10.

Acid or alkaline nature of a solution depends on whether hydrogen or hydroxyl ions predominate. Ionic theory is that salts, acids and bases are torn apart by water molecules to form positively or negatively charged fragments called ions. When acids are mixed with water, hydrogen ion is one result of the breakup.

In a mixture of bases and water, hydroxyl ions result. Hydrogen ions make a solution acid; hydroxyl ions tend to make it alkaline. When the solution contains one OH ion for every H ion, acid effect of one balances the alkaline effect of the other. Result is a neutral solution with a pH of 7.0.

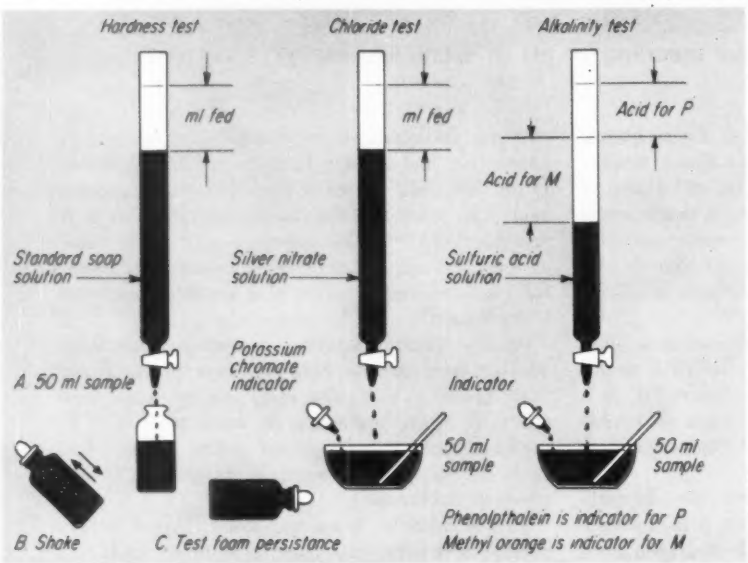
Equivalent weights are a handy tool for calculations

Chart at right tabulates both epm and ppm (expressed as calcium carbonate). Values for the various ions are taken from typical analysis on facing page. Any analysis can be checked quickly by adding equivalent cations and anions. For convenience, if negative anions are higher, balance is usually considered sodium. If totals are way out of balance, the analysis is probably in error. If cations are in excess, the missing anions may be nitrates, provided the remaining part of analysis is both complete and correct. In all cases positive cations must equal negative anions.

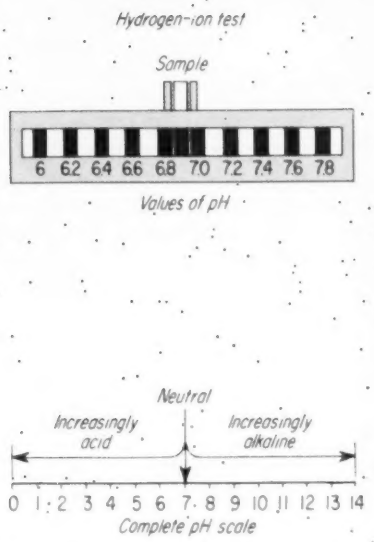
Water analysis	Ionic ppm	(+) epm cations	(−) epm anions	ppm as $CaCO_3$ cations	ppm as $CaCO_3$ anions
Magnesium (Mg)	31	2.54	—	127	—
Calcium (Ca)	62	3.10	—	155	—
Sodium (Na)	38	1.64	—	83	—
Bicarbonate (HCO_3)	250	—	4.10	—	205
Sulfate (SO_4)	138	—	2.87	—	145
Chloride (Cl)	11	—	0.31	—	15
Totals		7.28	7.28	365	365

ing equivalent weights. Calcium carbonate at 50.1 is 2.5 times greater than calcium at 20.1. So calcium carbonate equivalent of calcium in our analysis is 62x2.5, or 155 ppm. Tables giving conversion factors for all ions are available. This method of expression is accepted as the common standard basis of reporting a water analysis. It's particularly useful for in-plant treatment control.

An equivalent per million is a unit chemical weight equivalent per million units of solution. To get epm, divide concentration in ppm by the equivalent weight of the element or radical. Equivalents are particularly helpful in calculating amounts of reacting chemicals from equations. For example, our sample analysis has 250 ppm of bicarbonate. Dividing by 61 (equivalent weight of bicarbonate) we get 4.10 epm. When we know epm it's easy to find how much 90% calcium hydroxide will match and destroy the bicarbonate. Multiply epm of bicarbonate by equivalent weight of lime. This amounts to 4.10x41.1, or 168.5 ppm of 90% calcium hydroxide. Since 120 ppm equals 1 lb per 1000 gal, our 168.5 ppm becomes 1.4 lb per 1000 gal. The analysis also can be evaluated by totaling positive and negative ions separately. As shown above, the two columns always must be in complete balance.



TITRATION with ordinary laboratory glassware is one of many analytical methods available for analyzing water. It's commonly used for hardness, chloride and alkalinity tests


Hydrogen-ion test
Sample
6 6.2 6.4 6.6 6.8 7.0 7.2 7.4 7.6 7.8
Values of pH
Neutral
Increasingly acid
Increasingly alkaline
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Complete pH scale

COMPARATOR compares sample color with that of many standards to determine pH

Variety of test methods measure water impurities

Complete water analysis is a job for an experienced chemist. But every engineer should know how to make routine water tests such as are used in the daily operation of a water-treating system. Basic knowledge of testing methods is an extremely valuable tool when it comes to interpreting water analyses, selecting treatment systems and making operating adjustments on equipment.

There are usually many analytical methods available for each impurity or chemical substance in water.

Titration is one of the more commonly used procedures. Standard solution from a burette or calibrated container is added to the water sample. When the endpoint is reached, usually signalled by a color change in the sample, the burette solution level is noted. It's best to use an automatic burette which starts each titration at the zero mark, thus eliminating need for subtraction to get the amount of standard solution used. This reading is proportional to the amount of substance present.

Colorimetric methods also are widely used because of their simplicity. Test is based on developing a color in the sample proportional to amount of substance present. Then concentration of substance in sample is found by comparing its color with color standards of known concentration. Some comparators have color standards sealed in glass ampoules; others use standard colored-glass disks.

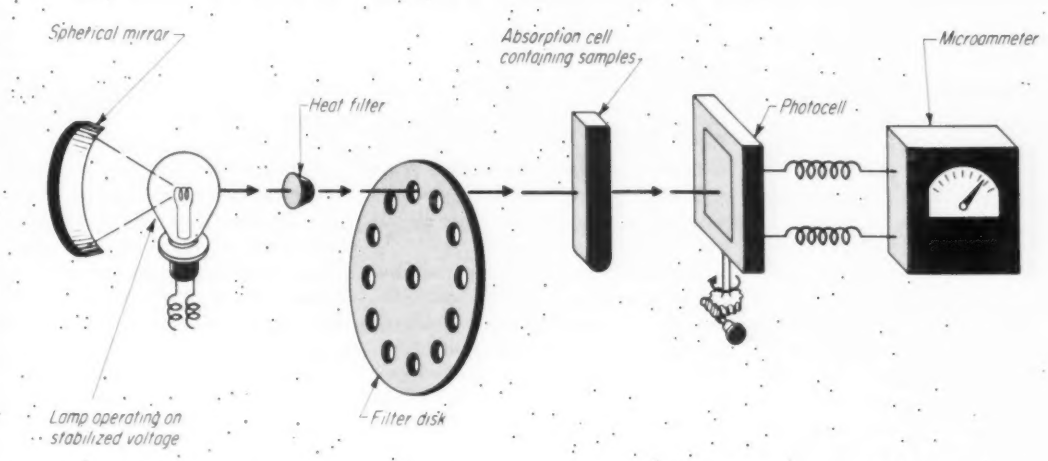
Water hardness can be found by several methods including (1) gravimetric analysis for calcium and magnesium (2) colorimetric titration (3) soap test (4) palmitate titration and (5) soda reagent procedure. Last two methods are rarely used. Gravimetric analysis is restricted to the lab for precise work; colorimetric titration and the soap test have proved very popular.

Soap test for hardness is shown above. Fill burette with standard soap solution (APHA), add to 50-ml sample of water in a bottle and shake until permanent lather forms (it lasts at least 5 min). Subtract 0.3-ml lather factor from total soap used. Multiply remainder by 20 to find hardness of sample expressed in ppm as calcium carbonate.

Chloride test calls for a burette filled with standard silver-nitrate solution. Take a 50-ml water sample and neutralize it by adding 4 or 5 drops of phenolpthalein indicator plus enough sulfuric acid to make solution colorless. Then add five drops of potassium-chromate indicator. This turns solution a bright yellow. Slowly add silver nitrate from the burette until one drop produces a permanent reddish color. Subtract 0.2 ml from amount of nitrate used and multiply remainder by 20 to find amount of chloride present in ppm as Cl.

Alkalinity titration is done in two steps. Fill burette with N/50 sulfuric acid (fiftieth normal). Then add 4 or 5 drops of phenolpthalein indicator to 50-ml sample of water. If water turns red, add acid and stir until color disappears. Note reading on burette. Now add four drops of methyl-orange indicator to give a yellow color. Continue adding acid and stir until color changes to reddish orange. Acid used in the first step multiplied by 20 equals P alkalinity in ppm. Acid used in second step plus first step multiplied by 20 equals M alkalinity in ppm. Both figures are expressed in terms of calcium carbonate. Box, on facing page, explains the relationship of P and M alkalinity in greater detail.

Hydrogen-ion concentration, expressed as pH is found in several ways. Simplest method uses color comparators and dye-indicator solutions that cover full range of 0 to 14 pH in a series of steps. For best re-



Photometers fill need for more accurate analysis

Place water sample in absorption cell, above. Turn on instrument to pass light from lamp and mirror combination through heat filter and filter disk. Select a filter that absorbs all light except wave length that is best for the test. Filtered light goes through solution in absorption cell. When white light enters a solution, some of it is absorbed. Light coming out gives a sensation of color to the human eye. Color depth or strength varies with its intensity. In this instrument photocell takes place of your eye, measures intensity of light rather than color. Electric current produced by photocell is proportional to light intensity on its face. So microammeter reading is proportional to color intensity. This, in turn, is proportional to concentration of the ion measured. Where extreme sensitivity is needed, spectrophotometers can be used to produce filtered light that is more nearly monochromatic. It's invaluable for the lab, but too expensive for routine control except in the larger plants.

sults select an indicator and color comparator that puts pH of sample somewhere near midpoint of comparator scale. Add ½ ml of color indicator to 5-ml water sample in test tube. As shown on facing page, compare resulting color with tinted liquid in comparator vials and read pH directly on scale when the colors are matched. If close pH control is important, or if color test is impractical, electrical measuring instruments called pH meters will indicate, record and control pH with a high degree of accuracy.

Complete instructions on all phases of water testing are contained in (1) *Manual on industrial water*, published by ASTM and (2) *Standard methods for the examination of water, sewerage and industrial wastes*, published jointly by the American Public Health Association and the American Water Works Association.

Here's what you should know about P and M alkalinity

Phenolpthalein (P) and methyl orange (M) alkalinity titrations don't indicate any one ion directly; they measure the many ions contributing to alkalinity including bicarbonate, carbonate, hydrate, phosphate, silicate, etc. So it's simpler to record results of analyses in terms of P and M alkalinity for plant control. However, alkalinity is usually expressed in bicarbonate, carbonate and hydrate forms. Standard practice assumes that (1) titration to P endpoint determines all hydroxide and one-half of carbonate alkalinity (2) methyl-orange titration measures sum of bicarbonate, carbonate and hydroxide. Table below gives the form of alkalinity in water for each of the five different P and M conditions.

P and M alkalinity	Hydrate (OH)	Carbonate (CO_3)	Bicarbonate (HCO_3)
$P = 0$	0	0	M
$P = M$	M	0	0
$P = ½ M$	0	M	0
$P < ½ M$	0	2P	M − 2P
$P > ½ M$	2P − M	2(M − P)	0

Chemicals play important basic role

Growing variety of chemicals are the foundation of water treatment. They may be added directly to fix dissolved oxygen, adjust the pH, neutralize carbon dioxide, form protective film on metal surfaces, etc.

Chemicals are also indispensable in most water-treating equipment. Salt, caustic and acid regenerate ion-exchange units; lime and soda ash precipitate hardness as an insoluble compound in both hot- and cold-process softeners; coagulants and coagulant aids help remove suspended solids in clarifiers. Table lists chemicals most generally used for coagulation, scale and corrosion control, disinfection, softening, etc.

Coagulant aids in organic polymer class are coming more into the picture. They help produce a tougher, faster settling floc than is possible with the coagulant alone. This often increases plant capacity, reduces amount of coagulant and other chemicals used in the treatment.

Hydrazine, neutralizing and filming amines are recent additions to the arsenal of weapons for combating corrosion. Complete reaction of hydrazine with oxygen produces nitrogen and water. No additional solids are added. One part of hydrazine reacts with one part of oxygen. Since it's available as a 35% solution about three parts are actually needed. Hydrazine also reduces ferric oxide Fe_2O_3 to the magnetic oxide Fe_3O_4, to increase heat transfer and boiler efficiency. If used in high enough concentrations, ammonium hydroxide forms as a byproduct of the reaction.

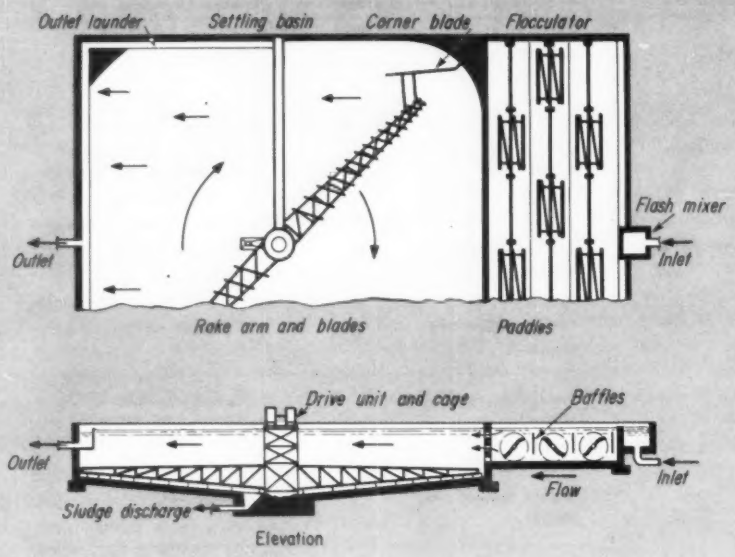
Neutralizing amines are typical of nitrogen-containing compounds used effectively to control corrosion in steam condensate systems. Both ammonia and amines such as morpholine and cyclohexylamine reduce iron pickup by raising pH and neutralizing carbon dioxide. About two ppm neutralizes each ppm of carbon dioxide.

Filming amines protect against both dissolved oxygen and carbon dioxide attack by forming a protective film on metal surfaces. About 2 to 3 ppm fed continuously is enough to form and maintain film.

Chemical and *common name*	Water-treatment use
Alum, ammonium $Al_2(SO_4)_3 \cdot (NH_4)_2SO_4 \cdot 24H_2O$ *Ammonia or crystal alum*	Coagulation
Alum, potassium $Al_2(SO_4)_3 \cdot K_2SO_4 \cdot 24H_2O$ *Potash alum*	Coagulation
Aluminum sulfate $Al_2(SO_4)_3 \cdot 14H_2O$ *Filter alum*	Coagulation
Amines, filming (Octadecylamine, etc)	Corrosion control
Amines, neutralizing (Morpholine, benzylamine cyclohexylamine, etc)	Corrosion control
Ammonium chloride NH_4Cl *Sal ammoniac*	Disinfection, corrosion control
Ammonium sulfate $(NH_4)_2SO_4$ *Sulfate of ammonia*	Disinfection (combined with chlorine), corrosion control
Anhydrous ammonia NH_3 *Ammonia*	Disinfection, corrosion control, activates silica
Antifoaming agents (Polyamides, polyalkylene-glycol derivatives)	Internal-boiler feedwater
Ammonium hydroxide NH_4OH *Ammonia water*	Disinfection (combined with chlorine), corrosion control
Calcium hydroxide $Ca(OH)_2$ *Hydrated or slaked lime*	Softening
Calcium hypochlorite $Ca(OCl)_2 \cdot 4H_2O$ *HTH, Perchloron*	Disinfection
Calcium oxide CaO *Chemical or unslaked lime*	Softening
Calcium sulfate $CaSO_4 \cdot 2H_2O$ *Gypsum*	Reduces excessive sodium carbonate and bicarbonate alkalinity
Carbon, activated *Carbo-Dur, Hydrodarco*	Taste and odor control
Chlorinated lime $Ca(OCl)_2—CaCl_2 \cdot H_2O$ *Bleaching powder*	Disinfection
Chlorine Cl_2 *Chlorine gas, liquid chlorine*	Disinfection; slime, algae, taste and odor control; activates silica
Chlorine dioxide ClO_2	Disinfection, taste and odor control
Chlorinated phenols Sodium pentachlorophenate Sodium trichlorophenate	Slime and algae control
Clay Bentonite	Coagulation aid

Chemical and common name	Water-treatment use
Copper sulfate $CuSO_4 \cdot 5H_2O$ *Blue vitriol*	Algae control
Dolomitic lime $CaO + MgO$ 58% CaO, 40% MgO	Softening with silica removal
Dolomitic lime, hydrated $Ca(OH)_2 + MgO$ 62% $Ca(OH)_2$, 32% MgO	Softening with silica removal
Ferric chloride *Ferrichlor* $FeCl_3$ (35-40% solution) Crystal ferric chloride $FeCl_3 \cdot 6H_2O$ Anhydrous ferric chloride $FeCl_3$	Coagulation
Ferric sulfate $Fe_2(SO_4)_3$ *Ferrisul, Ferrifloc*	Coagulation
Ferrous sulfate $FeSO_4 \cdot 7H_2O$ *Copperas*	Coagulation
Hydrazine hydrate $N_2H_4 \cdot H_2O$ *Hydrazine*	Oxygen scavenger
Hydrochloric acid HCl *Muriatic acid*	Alkalinity reduction and demineralizing (regenerant)
Magnesium oxide MgO *Magnesia*	Silica removal
Organic polymers Polyelectrolytes	Coagulation aid
Potassium chromate $K_2CrO_4 \cdot 10H_2O$	Corrosion control
Potassium dichromate $K_2Cr_2O_7$	Corrosion control
Potassium permanganate $KMnO_4$ *Permanganate*	Slime and algae control
Phosphoric acid H_3PO_4	Softening
Sodium aluminate $Na_2O \cdot Al_2O_3$ *Soda alum*	Coagulation
Sodium bisulfite $Na_2S_2O_5$ *Sodium metabisulfite*	Taste and odor control, iron removal from ion exchange units
Sodium carbonate Na_2CO_3 *Soda ash*	Softening
Sodium chloride NaCl *Salt*	Softening, dealkalizing (regenerant)
Sodium chromate $Na_2CrO_4 \cdot 10H_2O$	Corrosion control
Sodium dichromate $Na_2Cr_2O_7$	Corrosion control
Sodium hydroxide NaOH *Caustic soda*	Demineralizing (regenerant), softening and alkalinity adjustment
Sodium hypochlorite NaOCl	Disinfection
Sodium nitrate $NaNO_3$	Caustic embrittlement control, corrosion control
Sodium phosphate, mono $NaH_2PO_4 \cdot H_2O$ *Monobasic ortho phosphate*	Softening
Sodium phosphate, di $Na_2HPO_4 \cdot 12H_2O$ *Dibasic ortho phosphate*	Softening
Sodium phosphate, tri $Na_3PO_4 \cdot H_2O$, $Na_3PO_4 \cdot 12H_2O$ *Tribasic ortho phosphate*	Softening
Sodium phosphate, hexameta $(NaPO_3)_6$ *Polyphosphate*	Softening, scale and corrosion control
Sodium tripolyphosphate Sodium decaphosphate *Polyphosphates*	Softening, scale and corrosion control
Sodium silicate $Na_2O \cdot SiO_2$ *Water glass*	Coagulation, corrosion control
Sodium sulfite Na_2SO_3	Oxygen scavenger
Sulfur dioxide SO_2	Scale control and alkalinity reduction
Sulfuric acid H_2SO_4	Alkalinity reduction and demineralizing (regenerant)
Tannins, alginates, starches, glucose and lignin derivatives *Organics*	Scale and corrosion control, boiler-water coagulation
Quaternary ammonium compounds (Alkyl dimethyl benzyl-ammonium chloride, etc)	Slime and algae control

Flash mixing, flocculation and settling produce clarified water



Water enters flash mixer, left, and is mixed rapidly with coagulant by a rotating stirrer. Water, coagulant and finely dispersed precipitates are then given a gentle mixing as they flow through rotating paddles in flocculator. This promotes the growth of small particles of turbidity, color and precipitates into larger sized floc that settles more readily. Settling basin receives this mixture through submerged ports on its right side. Detention time varies anywhere from two to six hours. Basin is equipped with a rotating vertical shaft with radial arms and rake blades that just clear bottom. Solids settled from the water are raked inwardly to a central discharge hopper and removed continuously. Clarified water then flows into collecting flume at far left.

Clarification is usually first step

Clarifying water is process of removing turbidity and sediment. It's usually first step in treatment since most applications call for water that is essentially clear and colorless. However, as shown later, it can be combined with lime softening in one unit.

Coarse particles settle rapidly and are sometimes removed economically by flowing water through a basin at velocities low enough to let sand and silt settle. This happens naturally in many ponds and lakes if the water is quiet enough. Suspended matter settles leaving a clear if not always colorless water supply.

More common clarification calls for specially designed equipment and use of coagulating chemicals. Two typical systems are shown above. Filters are also employed to remove suspended matter by a mechanical screening action. Settling equipment normally precedes filtration to lighten load on the filters by removing bulk of suspended matter. But if raw water turbidity isn't too high, filters often handle the job alone. There are times when water from basic settling tanks does not require any filtration.

Coagulation is the gathering together of finely divided or colloidal suspended matter into larger particles. In this way coagulating agents speed up settling of suspended matter in water-treating equipment.

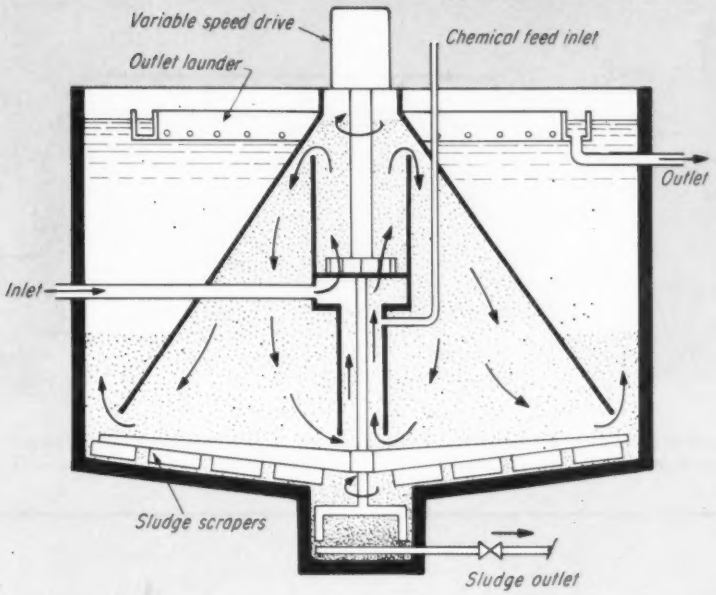
Coagulants such as aluminum sulfate (alum), sodium aluminate, ferrous sulfate (copperas), ferric chloride, etc, produces a jelly-like spongy mass called floc. It has an enormous surface area per unit of volume that traps, absorbs particles of turbidity, organic matter, bacteria. Although floc formation is a chemical reaction, the gathering in or adsorption of suspended solids is a mechanical process.

Aluminum compounds, especially alum and sodium aluminate are the most widely used coagulants. They both precipitate a relatively tough, heavy aluminum-hydroxide floc that has remarkable ability to remove suspended solids from water. Iron salts such as ferric sulfate, precipitate ferric-hydroxide floc over a wide range of pH values. But for each specific use pH must be closely controlled. In practice this is done by feeding an acid or alkali such as lime, soda ash or caustic soda. Clay, activated silica, organic polyelectrolytes and other aids are used to foster coagulation. In general coagulant aids help produce larger and heavier floc particles over wider pH ranges with greater ability to remove turbidity.

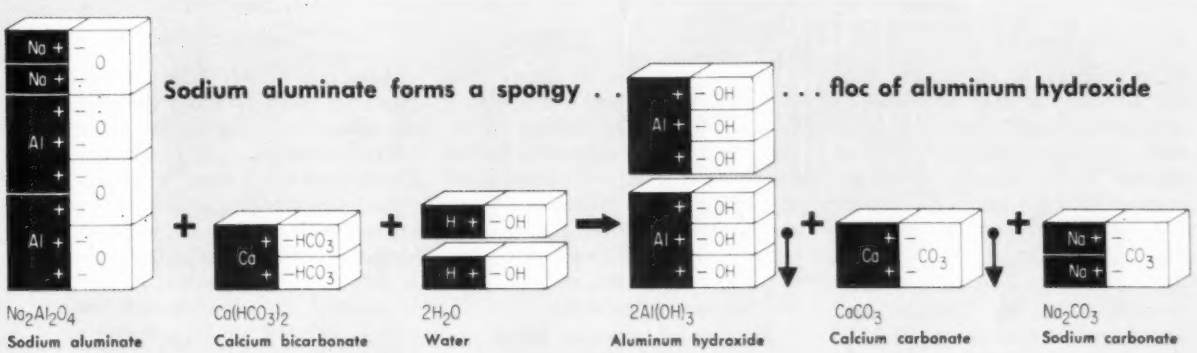
Alum reacts with soluble alkalis to form aluminum hydroxide. This compound is practically insoluble over the pH range of 5.7 to 7.5. Particles of aluminum hydroxide are positively charged and repel each other. But negative ions in water such as chlorides, carbonates, sulfates, clay and bacteria neutralize these positive charges and allow coagulation into visible floc.

Aluminum hydroxide dissolves and ionizes as a negative acid in the pH range below 5.7; as a positive alkaline compound above a pH of 7.5. The useful insoluble compound forms best in the pH zone between these limits. So from a chemical standpoint coagulation with alum depends on

Many clarifier designs combine mixing and coagulation in same unit



Raw water enters lower part of central uptake, is mixed with treatment chemicals and precipitates from bottom of the unit. Mixture of water and chemicals is lifted through central uptake by a variable-speed agitator and discharged into the main mixing chamber where reactions are brought to completion. Some water and suspended precipitates enter lower end of the uptake for recirculation and contact with incoming chemicals and raw water. New floc formation is encouraged by contact with these previously formed precipitates. Rest of water enters outer settling section. Lighter precipitates are kept suspended and clarified water rises to the outlet flume above. Heavier particles settle and are moved along bottom by a rotating scraper to central sludge pit.



both the water analysis and the pH after adding the alum.

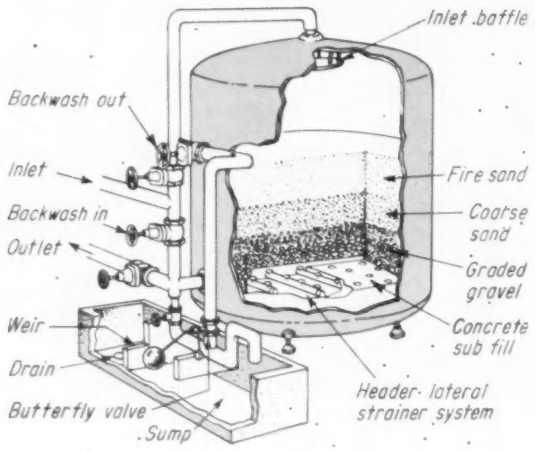
When there is natural alkalinity in the water, aluminum sulfate hydrolizes into aluminum hydroxide, liberating sulfuric acid. This reacts with alkalinity to form calcium sulfate and carbon dioxide. Each ppm alum added consumes about 0.5 ppm of natural alkalinity. If alkalinity isn't high enough, lime or soda ash is added. It takes 0.4 ppm of lime (90% calcium hydroxide) or 0.5 ppm soda ash for each ppm of alum.

Actual amount of lime or soda ash added is controlled to give the best pH value for the coagulated water.

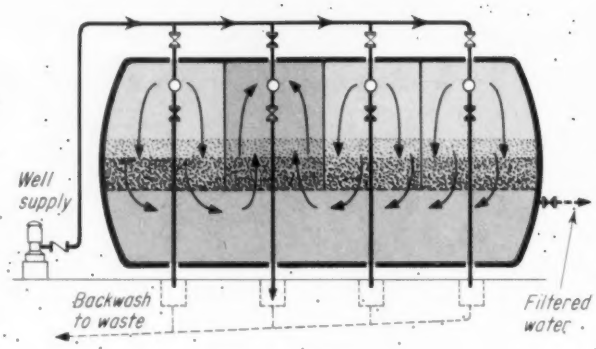
Amount of alum needed is almost impossible to calculate. Only practical way is to run lab-jar field tests under actual operating conditions and find best dosage by the trial-and-error technique. Actual amount will vary with fineness and quantity of turbidity, water temperature, amount of mixing, etc. Optimum results one day may not be correct on the next.

Since sodium aluminate is slightly alkaline, it's often added with alum for low pH coagulation. But usually it's combined with lime and soda ash in a softener for coagulation at high pH. Sodium aluminate, above, reacts with calcium bicarbonate, throwing calcium carbonate out of the solution to produce aluminum-hydroxide floc. This floc envelopes both particles of precipitated calcium carbonate and suspended matter for easy settling and removal.

There are no simple rules to guide your choice of a coagulant, coagulant dosage, coagulant aid or pH range. Too much depends on the water analysis, temperature of water, type of clarification equipment, load conditions and end use of the treated water. But a few simple tests conducted under actual operating conditions will point the way to best results at the lowest overall treatment cost.



PRESSURE FILTERS operate at rates of 2 to 4 gpm per sq ft. Filter sizes range from 1 to 11 ft in diameter; 4 to 5 ft in height



HORIZONTAL FILTERS may be divided into sections. Here, we take filtered water from any three cells to backwash one cell

Many filter designs compete for job of clarifying water

Water is filtered by passing it through fine strainers or other porous media to remove suspended solids mechanically. Degree of filtration depends on fineness of the filtering media and type of filter aid used.

In pressure or gravity designs, above, raw water flows down through graded layers of sand and gravel, anthracite, calcite, etc. Clarified water is collected at the bottom. If filters follow settling tanks, a light floc comes over to form a mat on the filter bed. This keeps any finely divided particles from passing through. When filters are used alone, a separate coagulant feed is needed.

Cleaning filters for effective filtration is important. Frequency of job varies with allowable head loss through the filter (usually 8 to 12 ft). Practical limit is when floc or turbidity appears in outlet.

Backwashing with clarified water is most common cleaning method. Backwash rate varies with water temperature, but is usually in the range of 10 to 20 gpm per sq ft and is chosen to give at least 50% bed expansion. While this keeps grains of filter media close enough to rub each other clean, it doesn't lift them high enough to be lost down the drain. Rinsing puts another mat on the filter before it goes back in service.

Pressure filters are popular because they can be installed in piping systems without repumping. They also permit high-temperature operation without heat loss. Gravity designs, a must for municipal treatment, are generally preferred for handling larger flows. Individual units come in many sizes, shapes, materials, and use numerous filter media.

Horizontal pressure filters can pose the problem of high backwash flows because of large filtering area in each unit. But when filter is compartmented, above, only one section at a time is backwashed. This means lower backwash flows.

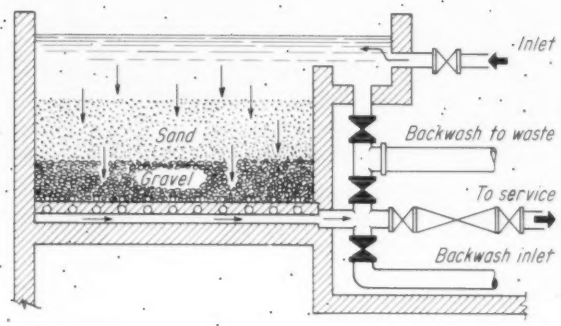
Valveless gravity filter, top right, facing page, is a relative newcomer. During operation, the water level rises slowly in backwash pipe. At preset level or head loss it automatically spills out the pipe to waste. Water then flows up through the sand bed from backwash storage and out the same pipe. Backwashing stops when end of siphon breaker is exposed. Unit rinses and returns to service without any operating attention.

Another unique gravity filter, lower left, facing page, is divided into many compartments. An overhead carriage has pumps for backwashing. Carriage moves automatically and backwashes each filter section in turn.

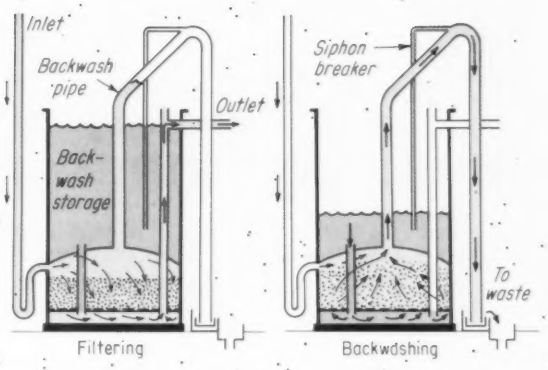
Leaf and tubular filters both employ filter aids to form a cake on their elements. Leaf design handles moderate turbidities, can be used for direct filtration of some water in place of coagulators and sand filters. Operating cost tends to be higher, but equipment cost is usually less and operation is simpler. Entire internal assembly is removed for cleaning and filter cake is stripped off by a shaker or vibrator attachment.

Tubular filter-element units store their own backwash water. Air pressure builds up during run. To backwash, close outlet, then inlet valve. Open air release valve. This forces water through the filter elements in reverse direction at extremely high rates. Filter cake is blasted loose from the elements and drained off.

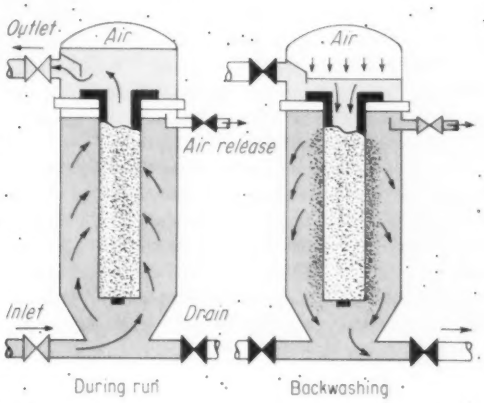
Cartridge filters are widely used for polishing water. Since fine solids in the size range from 1 to 75 microns are readily removed, it's important to know size of the particles in the water. Best foundation is a wet-screen analysis of these solids with an idea of the maximum particle size. When pressure drop reaches 25 to 30 psi, economical life of the cartridge is reached and it must be replaced. These cartridges come in many different materials and some are designed for mechanical self-cleaning.



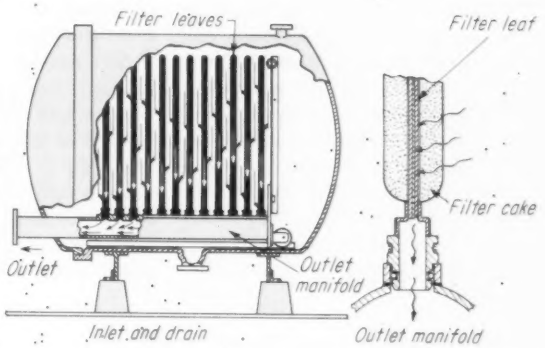
GRAVITY DESIGNS handle large flows economically. Rectangular shape and reinforced concrete construction are most widely used



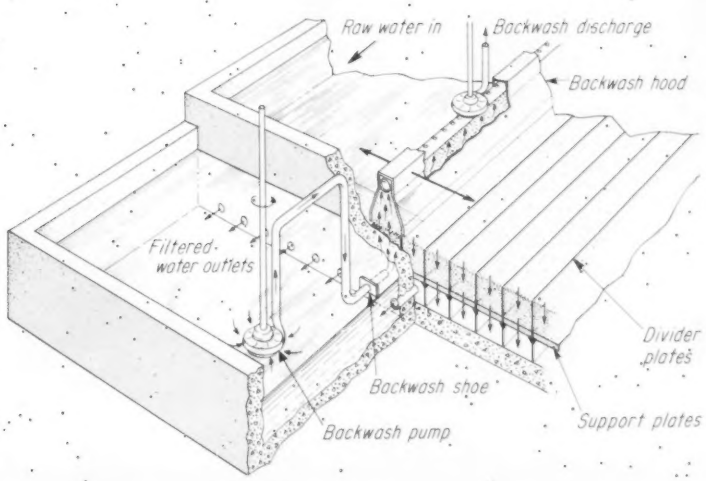
VALVELESS GRAVITY FILTER automatically backwashes at preset head loss, rinses and returns to service without human attention



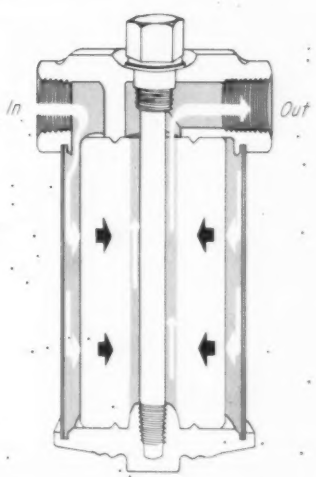
TUBULAR FILTERS often use filter aids like diatomite to form a filter cake on each element. Backwash is powered by air pressure



LEAF DESIGNS also use filter aids. Entire unit of leaves, head and manifold are removed through quick-opening door for cleaning

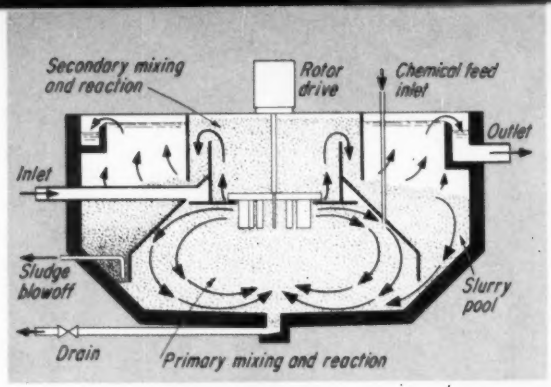


COMPARTMENTED GRAVITY DESIGN has moving overhead carriage equipped with backwash pumps. Each filter-bed section is backwashed automatically in turn with filtered water



CARTRIDGE FILTERS use disposable type elements to remove fine solids from water

Lime softeners tame four raw-water impurities



SOLIDS-CONTACT EQUIPMENT mixes incoming raw water, treatment chemicals with solids formed previously in lower mixing zone

Four of water's most troublesome impurities are removed effectively by chemical reaction with combinations of lime, soda ash and caustic. (1) Calcium hardness precipitates as calcium carbonate and magnesium hardness as magnesium hydroxide. (2) Bicarbonate alkalinity is first converted to carbonate form and then removed as calcium carbonate. (3) Silica comes out as an insoluble silica-magnesium complex when it reacts with magnesium hydroxide. (4) Turbidity from suspended solids and magnesium hydroxide and calcium carbonate sludge is removed by settling and filtration.

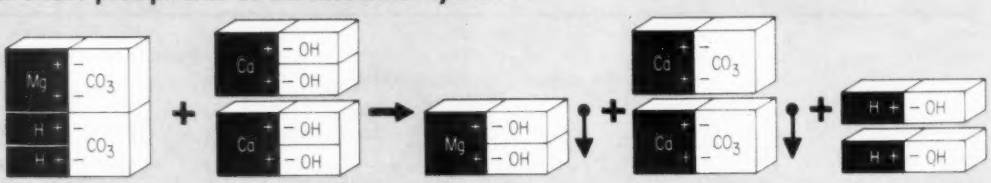
Cold process is the term used when these reactions are carried out at room temperature. Solids-contact units, shown above, handle this job with a detention time of 60 to 90 minutes. When water is heated well above room temperature it's called a hot process. This equipment, covered later, actually operates above 212 F. All these units are designed for continuous operation. Batch type treatment is seldom used today.

Now let's take a close look at hardness and its removal by precipitation. Calcium and magnesium in water are present as either carbonate or noncarbonate hardness. Bicarbonates of calcium and magnesium are the carbonate hardness. Boiling will destroy it by driving off carbon dioxide and precipitating carbonates. This is easier to visualize when you have a complete understanding of how both carbonates and bicarbonates react.

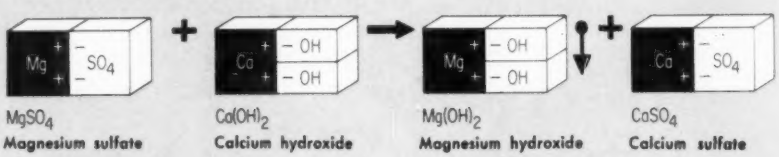
Free carbon dioxide and water (carbonic acid) react with calcium hydroxide to form calcium carbonate. Calcium carbonate then reacts with more carbonic acid to produce soluble calcium bicarbonate. If enough carbon dioxide is present, all carbonates will be converted to soluble bicarbonates.

Now suppose there is just enough carbon dioxide to change all hydroxide to carbonate form, but only part of the carbonates to bicarbonates. This water then contains both carbonates and bicarbonates, but no free carbon dioxide. All carbon dioxide

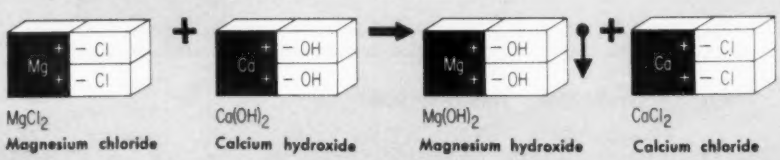
Carbonate hardness precipitates as an insoluble hydroxide

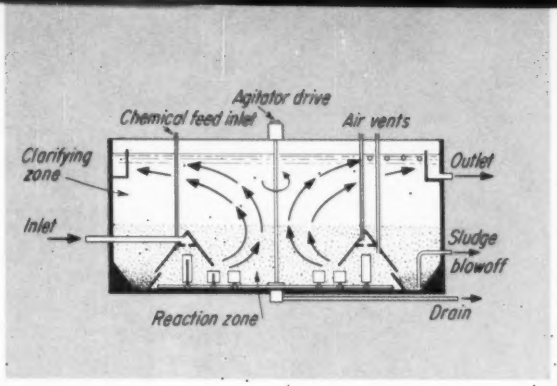


Lime treatment is first step in removing noncarbonate hardness

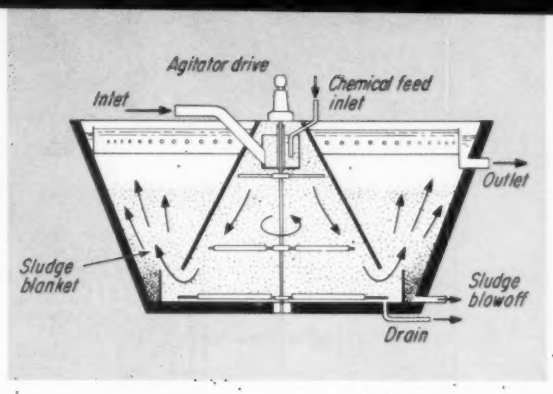


Magnesium hydroxide is precipitated, but reaction forms calcium hardness





FLOW RATE of this design ranges from 0.75 to 2.0 gpm per sq ft of top surface. Low range is for coagulation; high range for softening



SLUDGE BLANKET containing the chemical precipitates is kept in suspension by combined mechanical agitation and hydraulic flow

in the carbonate radical is termed *firmly bound*, along with half that in the bicarbonate. Remaining half of the carbon dioxide in bicarbonate is called *half bound*. If this water is boiled to remove carbonate hardness, it's the half-bound carbon dioxide that comes off when bicarbonates are converted to carbonates.

Noncarbonate hardness is present as sulfates, chlorides and nitrates of calcium and magnesium. These neutral salts aren't precipitated by heat, but calcium sulfate forms a hard scale when water is evaporated and concentrated. To show how noncarbonate hardness precipitates as a harmless compound, we'll first explain what happens to materials in solution.

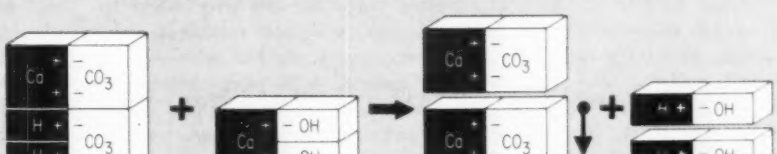
Solubility is the amount of solid that can be dissolved in a solute, in this case, water. For example, add common salt to water and stir. You'll find it dissolves until it reaches a point where no more goes into solution. Take this solution and filter it to remove any undissolved salt. Then evaporate the water and weigh the amount of salt that remains. If there are 3 lb of salt for each gallon of water evaporated, this is the solubility of salt in water at that temperature. If a solution contains less than this, nothing happens during evaporation until the concentration of 3 lb per gal is reached. Then salt starts coming out of the solution.

Precipitation takes place in simple cases of boiling or evaporation because solubility of the compound is exceeded. But when several substances are dissolved in the same solution it's a more complex problem.

Suppose we have one compound in solution and add another that's also completely soluble by itself. These two compounds may react chemically. One product of the reaction may be less soluble than either of the original compounds. It will then precipitate or come out of solution because of the chemical change.

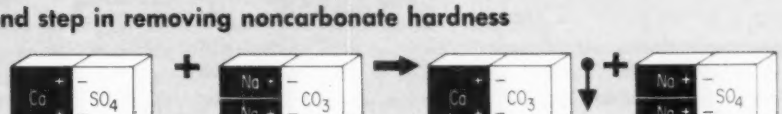
As inorganic chemicals dissolve in water they dissociate or break into ions. Calcium sulfate forms calcium and sulfate ions; sodium phosphate separates into sodium and phosphate

Lime also removes carbonate hardness as insoluble calcium carbonate



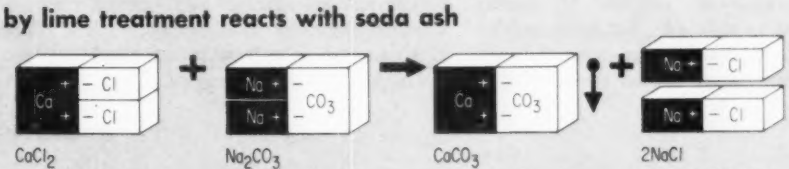
$Ca(HCO_3)_2$ Calcium bicarbonate + $Ca(OH)_2$ Calcium hydroxide → $2CaCO_3$ Calcium carbonate + $2H_2O$ Water

Soda-ash treatment is second step in removing noncarbonate hardness

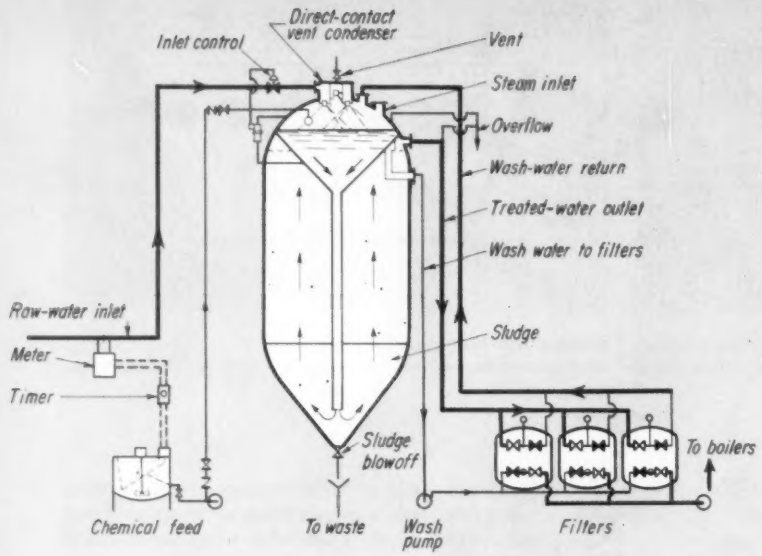


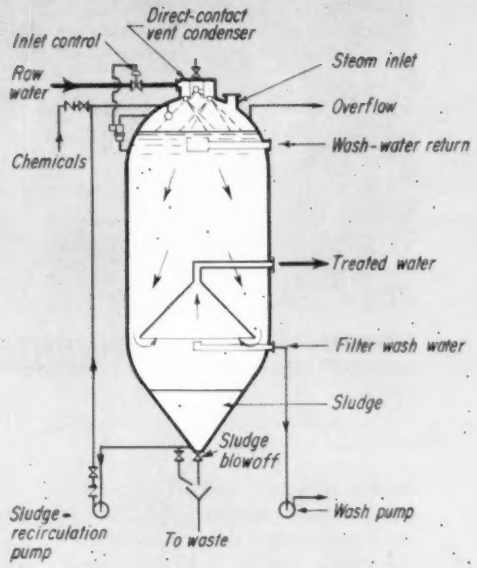
$CaSO_4$ Calcium sulfate + Na_2CO_3 Sodium carbonate → $CaCO_3$ Calcium carbonate + Na_2SO_4 Sodium sulfate

Calcium hardness formed by lime treatment reacts with soda ash



$CaCl_2$ Calcium chloride + Na_2CO_3 Sodium carbonate → $CaCO_3$ Calcium carbonate + 2NaCl Sodium chloride





HOT-PROCESS SOFTENER mixes steam, raw water and chemicals in upper zone. Water then flows to bottom, rises through sludge blanket and discharges to anthracite filters

DOWNFLOW DESIGN uses recirculated sludge. Usual detention time is 60 minutes

Hot-process softeners use steam for more efficient removal

ions. When both are present in water we not only must know their own solubility, but that of their reaction products—sodium sulfate and calcium phosphate.

Solubility product of the various ion combinations is used to predict what compounds, if any, will precipitate. In our example, calcium sulfate has a solubility of 1.07 grams per liter. Divide 1.07 by its molecular weight of 136 to get a gram molecular weight of 0.0079 each for calcium and sulfate. The solubility product is then 0.0079 (0.0079) or 0.000062 (6.2×10^{-5}). This is much greater than calcium phosphate's solubility product of 3.5×10^{-19}. So calcium ions precipitate as calcium phosphate instead of calcium sulfate. The sulfate won't precipitate as long as there is excess phosphate present.

Treatment chemicals are generally used to lower solubility product of scale-forming impurities and to precipitate them as a sludge.

Either lime or caustic soda gives hydroxide for precipitation of magnesium hydroxide. Carbonate needed to precipitate calcium is usually added as soda ash. But some carbonate is available when natural bicarbonate is converted to carbonate form by use of lime or caustic soda.

Although raw water may contain enough magnesium to reduce silica content, it's usually added in pure form as magnesium oxide or as a component of dolomitic lime.

Cold-process treated water is never completely softened because (1) it takes too long for reactions to go to completion and (2) both calcium carbonate and magnesium hydroxide are slightly soluble in water. Theoretically residual hardness can be reduced to 25 ppm. Actually it's rarely taken below 50 ppm. Lowest silica residuals produced by cold-process treatment of high-silica waters are in the range of 3 ppm.

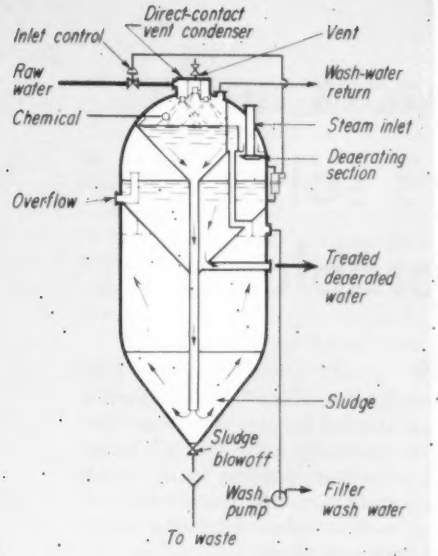
After-precipitation of calcium carbonate sludge from treated water is a problem posed by the high lime excess needed to complete the reactions in cold-process softeners. One solution is to recarbonate by passing carbon-dioxide gas through the softened water. This neutralizes any excess lime and converts residual calcium carbonate to soluble bicarbonate. Organic and phosphate surface-active agents also retard after-precipitation.

Hot-process softeners are used for boiler-feedwater treatment. Units, above, operate at 212 F or higher. Heat source is live or exhaust steam.

Cold water enters unit through a float-controlled regulating valve in response to water-level changes in the sedimentation tank. Water is heated by spraying it into the upper steam space. Inlet flow actuates a proportioning device to control amount of lime and soda ash fed to the heating and mixing zone. Chemical reactions, already described, take place almost instantly. Sedimentation proceeds at a rapid pace because of the elevated temperature. Sludge collecting cone at bottom receives the precipitates and discharges them to the sewer periodically. Clarified water leaves the settling tank and is fed to the anthracite filters for polishing.

Hot-process equipment is capable of treating large flows in relatively small units. Chemical dosages are much lower than required by cold-process units. Treatment jobs handled by the hot-lime soda softener include (1) softening by removing calcium and magnesium (2) silica removal with magnesium salts (3) oxygen removal and (4) removing turbidity.

Treated water is comparatively stable compared to cold process. However, any marked increase in



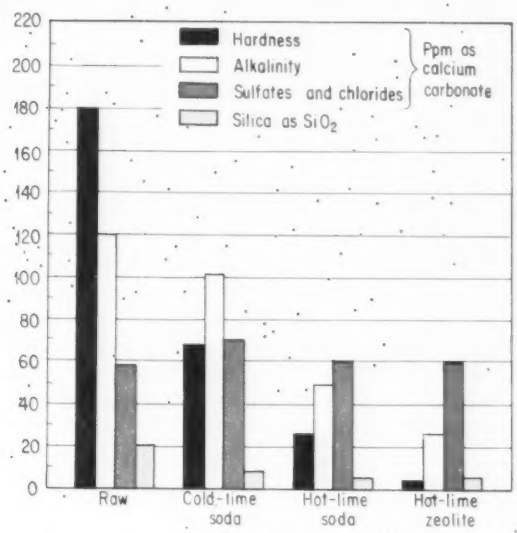
DEAERATING SECTIONS can be added to remove oxygen from the softened water.

of hardness, silica

temperature such as in economizers or closed heaters may cause after-precipitation. Then supplementary chemical treatment is called for to prevent any objectionable deposits.

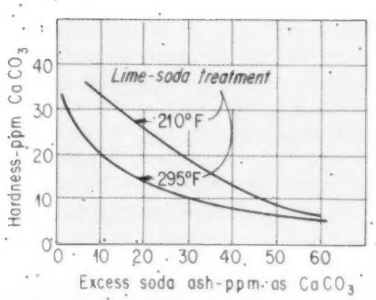
Controlling a hot-process unit is generally more difficult than controlling a zeolite softener since more test and adjustments must be made. Hot-lime zeolite system, below, combines best features of both units.

Here's how cold- and hot-process compare

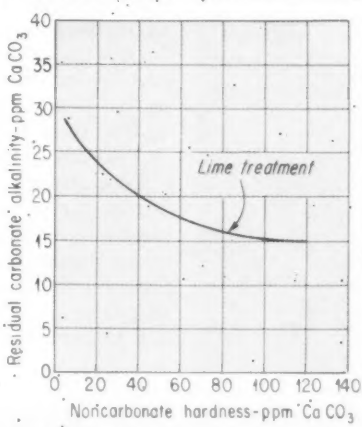


Raw-water analysis selected for this comparison is at left. Cold-lime soda reduces hardness, alkalinity and silica. Note that both hot-process methods do a more complete job of removal. Silica is reduced to 1 ppm compared to 8 ppm for cold process. Residual hardness from the hot-lime soda is 27 ppm. This is actually reduced to zero when hot process is followed by a salt-regenerated cation exchanger. Called the hot-lime zeolite process, it produces the best water in this comparison. Alkalinity is lower since soda ash isn't needed for low residual hardness in the settling tank.

Hot-lime zeolite produces treated water with zero hardness and low alkalinity



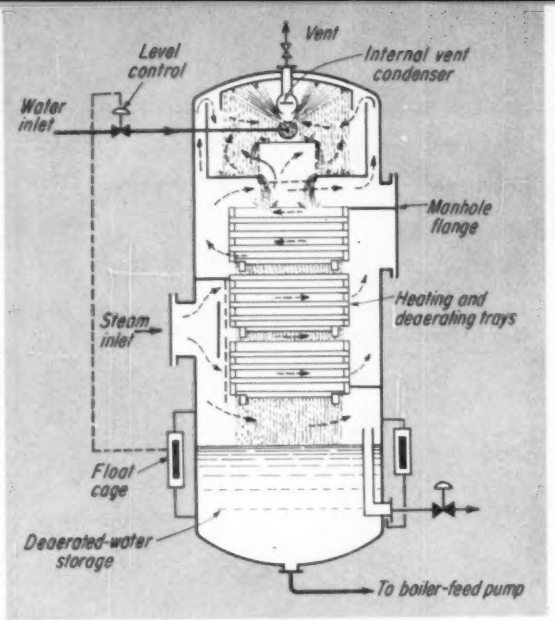
RESIDUAL HARDNESS depends on excess carbonate that remains in treated water.



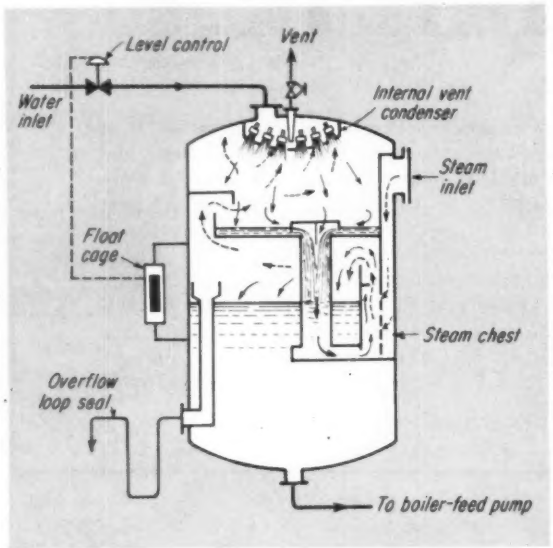
LIME TREATMENT leaves a higher residual hardness, with alkalinity of 15 to 25 ppm.

Development of ion-exchange resins for use at high temperatures made the hot-lime zeolite system possible. Effluent hardness is zero compared to 27 ppm from a hot-lime-soda unit. Curve, far left, shows that 20 ppm excess soda ash is needed to produce this residual hardness. Resulting alkalinity is in range of 45 to 50 ppm. Alkalinity from hot-lime-zeolite runs from 15 to 25 ppm. Curve, left, shows the residual carbonate alkalinity and noncarbonate hardness from lime treatment. This residual hardness is removed by the hot zeolite. It's less costly from the chemical angle to remove this hardness with salt in a cation exchanger than with soda ash in the hot-process settling tank.

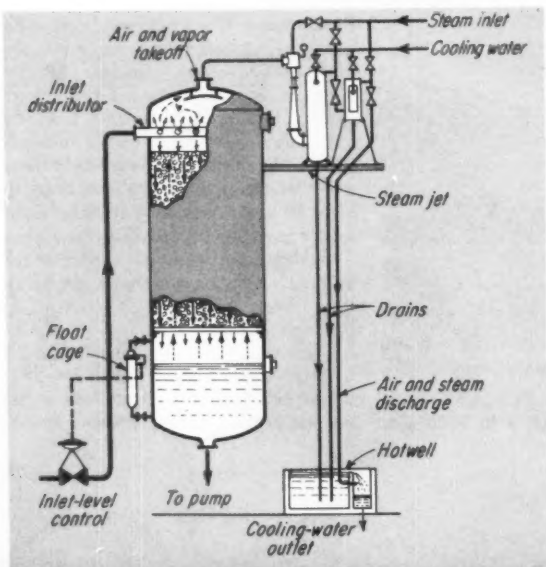
Deaerators and aerators solve many problems



TRAY-SPRAY DESIGN cascades water over trays after initial spraying at top. Crossflow of steam does heating, removes gas



SPRAY DEAERATOR agitates, mixes water with incoming steam to scrub out last part of dissolved gas before water leaves unit



Oxygen is a dissolved gas that doesn't react chemically with water and becomes less and less soluble as water temperature increases. So it's easily removed by bringing water to the boiling point corresponding to its operating pressure. Pressure and vacuum designs are used.

When it's necessary to heat water—for boiler feed—steam deaerators are employed. If water is used for cooling or other purposes where heating isn't needed or wanted, vacuum units are practical.

Steam deaerators break up water into a spray or film and then sweep the steam across and through it to force out dissolved gas like oxygen or carbon dioxide. Oxygen content can be reduced below 0.005 cc per liter, almost the limit of sample testing by chemical means. As carbon dioxide is removed, the increase in pH also gives an indication of deaeration efficiency.

Typical deaerator has a heating and deaerating section plus storage for hot deaerated water. Usually a separate tank is provided alongside or underneath unit to hold ten minutes' storage at rated capacity.

Design of steam deaerators falls into two broad types: (1) spray (2) tray or combination spray-tray. Entering steam, lower left, meets hottest water first to thoroughly scrub out the last remaining fraction of dissolved gas. This gas is carried along with the steam as it flows through the deaerator. Actual direction of steam flow varies with the design and may be crossflow, downflow or countercurrent flow. Steam picks up more noncondensable gas as it goes through the unit and condenses as it heats the water.

Bulk of steam condenses in top of the deaerator when it contacts entering cold water. Remaining mixture of noncondensable gases like oxygen and carbon dioxide are discharged to atmosphere through a vent condenser. For more information refer to *Standards and typical specifications for deaerators and deaerating heaters* published by The Heat Exchange Institute. POWER's special report on *Heat exchangers*, June 1954, also is helpful.

Vacuum deaerators use steam-jet ejectors or mechanical vacuum pumps to pull the required vacuum. Degree of vacuum depends on water temperature and is usually in range of 28 in. Hg. Efficiency of oxygen and carbon dioxide removal doesn't compare with steam units. Oxygen residuals run about 0.2 ppm; carbon dioxide will vary from 2 to 10 ppm depending on amount coming in and temperature of the water. Vacuum deaerator units

VACUUM DEAERATOR rains cold water down through packing. Steam-jet ejectors pull vacuum; remove oxygen, CO_2, nitrogen

are often used in demineralizing systems to reduce chemical operating costs, equipment size and to protect anion-exchange resins from any oxidation damage. Packing consists of staggered wood-slat packing or ceramic Raschig rings.

Aeration is simply a mechanical process for mixing air and water intimately. It can be done with spray nozzles, cascade aerators, pressure aerators or forced-draft units. For low flows, it's also practical to bubble air through the water in a storage tank.

Forced-draft degasifiers, right, are commonly applied for carbon-dioxide removal, although they also do a good job of removing hydrogen sulfide and oxidizing iron and manganese.

Packing in the degasifier consists of horizontal wood-slat trays or Raschig rings that divides the falling water into many small streams. Air is forced up through the unit by a blower and distributed over the lower cross section of the tank. It flows upward countercurrent to the flow of water. Air and gas scrubbed from the water are discharged through the vent at top.

Forced-draft units are extremely efficient for gas removal, and they are less expensive than vacuum deaerators for carbon-dioxide removal. Result: many demineralizing systems have them to reduce carbon dioxide to the level of 2 to 5 ppm. But disadvantages of treated water that's saturated with oxygen often outweigh any cost advantage of the forced-draft design for this use.

Pressure aerators are sometimes employed to oxidize iron and manganese where open aerators and double pumping are undesirable. Unit at right saturates only a portion of the water flow with air, so amount of dissolved air present in the total flow won't be greater than amount that the water can hold in solution at atmospheric pressure. Theoretically each ppm of dissolved oxygen oxidizes about 7 ppm of iron or manganese.

This saturator doesn't reduce the free carbon-dioxide content. And since the effluent usually flows directly to the filters without settling, its use is limited to waters having low iron, manganese and carbon-dioxide content.

Coke-tray aerators are more widely used to aerate iron- and manganese-bearing waters. Unit, right, consists of a series of coke-filled trays. Water enters at the top through a float-controlled inlet valve, percolates through the coke and is aerated during free fall over the trays.

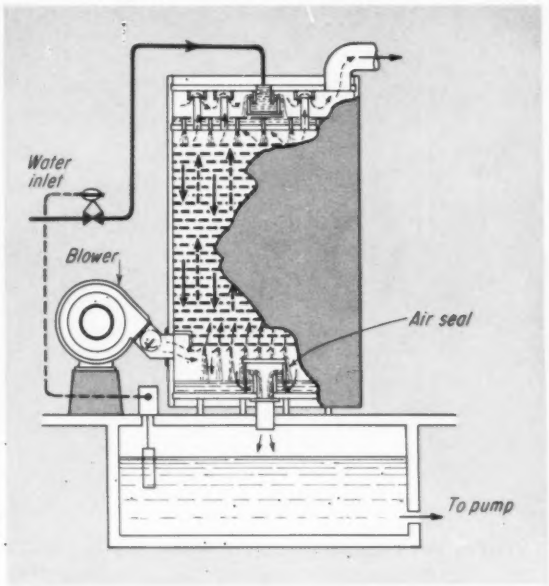
Iron oxide precipitates out on the coke where it contacts incoming iron-bearing water and acts as a catalyst to help bring down more iron.

Wood-slat aerators have a similar design. Trays are staggered to break up the free fall of water and expose the water surface to the air before dropping into the basin below. They are similar to small cooling towers.

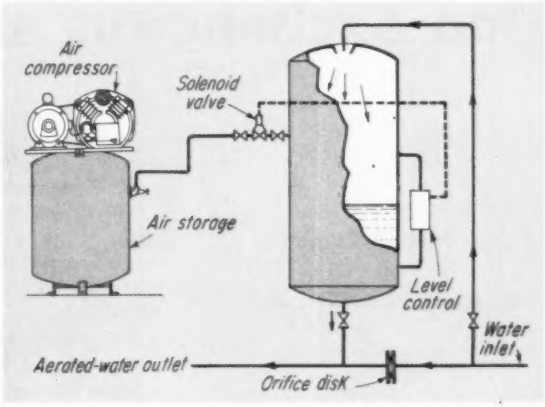
Air-diffusion method consists of bubbling air through a solid mass of water. This is done by forcing air through strainers, perforated pipes, porous plates or tubes at the bottom of a tank containing the water. Large volumes of air needed for efficient gas removal limits use of this method to smaller flows.

Spray aerators sweep out any volatile substances by mechanical spraying action. Spray nozzles are usually mounted above an open basin and discharged into the air. In municipal plants they are used to remove taste and odors from algae decomposition and hydrogen sulfide.

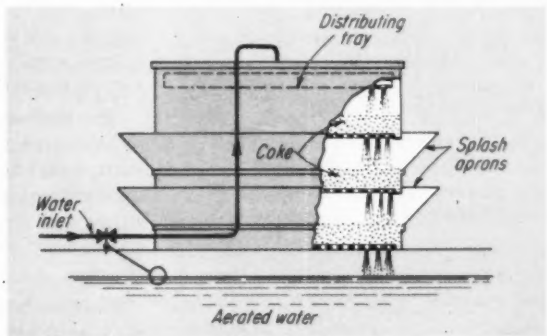
Air removes carbon dioxide and oxides iron



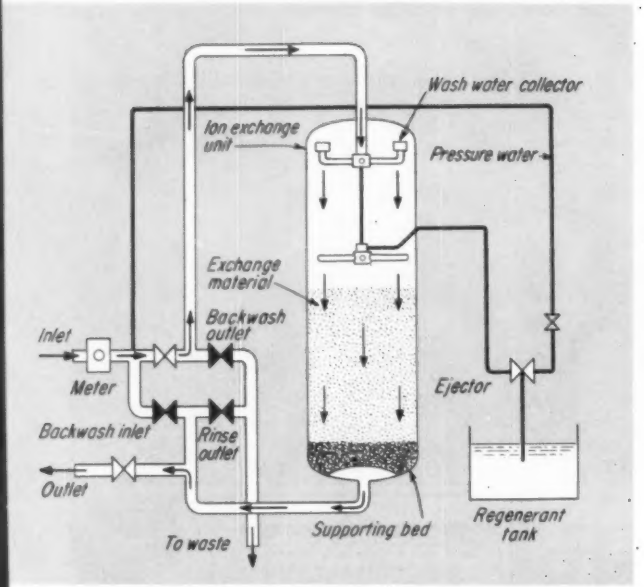
FORCED-DRAFT DEGASIFIER blows air stream through packing countercurrent to downward flow of water to remove CO_2



PRESSURE AERATOR supplies air for oxidation of soluble ferrous iron to insoluble ferric form for later removal by filtration



COKE-TRAY AERATORS are widely used for iron removal. Incoming water contacts freshly precipitated iron oxide on coke



TYPICAL ION EXCHANGER showing service flow with valve nest for regeneration—backwashing, injecting chemicals, rinsing

Variety of exchange materials are used

Ion-exchange materials	Flow rate gpm per sq ft	Regeneration chemical	Regeneration lb per cu ft	Typical capacity kgr per cu ft
Cation exchangers				
Sodium cycle				
Natural greensand	5.0	NaCl	1.25	2.8
Synthetic gel	6.0	NaCl	5.0	10.0
Sulfonated coal	6-8	NaCl	3.15	7.0
Styrene resin	8-10	NaCl	10.0	25.0
Hydrogen cycle				
Sulfonated coal	6-8	H_2SO_4	2.0	8.0
Styrene resin	8-10	H_2SO_4	5.0	11.0
		H_2SO_4	11.0	25.0
		HCl	10.0	30.0
Anion exchangers				
Weakly basic (Aliphatic amine)	6.0	Na_2CO_3	4.2	18.0
Weakly basic (Phenolic)	6.0	Na_2CO_3	4.2	18.0
Weakly basic (Styrene)	6.0	NaOH	3.25	20.0
Strongly basic (Type I)	6.0	NaOH	4.0	11.0
Strongly basic (Type II)	6.0	NaOH	4.5	14.0

Ion exchange is a versatile tool

Here are terms commonly used in ion exchange

Zeolites are processed greensand deposits with ion-exchange properties. Although any ion exchanger is often called a zeolite, it's better to use a specific term like anion or cation exchanger

FMA stands for free mineral acidity and equals the total amount of strong acid in outlet of a hydrogen exchanger

TMA or theoretical mineral acidity is the sum of chlorides, sulfates, nitrates in raw water. It equals FMA if hydrogen exchanger is 100% efficient

Total exchangeable ions are those taken from water by ion exchange. For hydrogen units it usually equals sum of sodium, calcium and magnesium ions

End point of ion-exchanger run takes place when unexchanged ions in the outlet exceed preset limits

Exchange capacity is a measure of kilograins of ions removed per cu ft of exchanger before reaching the end point

Leakage is steady appearance of unwanted ions in an exchanger effluent. In hydrogen units it equals TMA-FMA

Impurities that dissolve in water dissociate to form positively and negatively charged particles known as ions. These impurities or compounds are called electrolytes. The positive ions are named cations because they migrate to the negative electrode (cathode) in an electrolytic cell. Negative particles are then anions since they're attracted to the anode. These ions exist throughout the solution and act almost independently. For example, magnesium sulfate ($MgSO_4$) dissociates in solution to form positive magnesium ions and negative sulfate ions. Generally, all natural waters contain electrolytes in varying concentrations.

Ion-exchange material has the ability to exchange one ion for another, hold it temporarily in chemical combination, and give it up to a strong regenerating solution. Chart, above, lists capacity of the ion exchangers commonly used in water treatment. Some of these like greensand have been in use a long time. Others such as the strongly basic anion resins are more recent developments. Styrene-cation resins are probably the most widely used today.

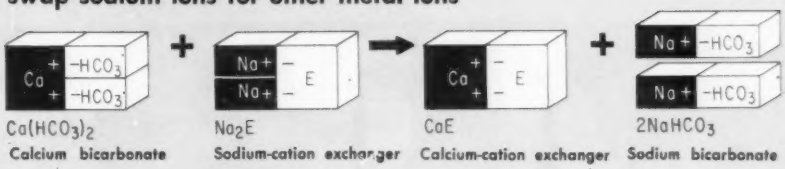
Ion exchanger, above, is much like an ordinary pressure filter. Bringing water in contact with the exchange material in this vessel starts the ion-exchange process. The unit is provided with piping and valves for washing and regeneration.

First basic treatment is softening. Let's fill our unit with styrene-base resin and start running water through it. As shown by building blocks, right, the water trades calcium and magnesium cations for sodium cations. This trading continues until the sodium-cation exchanger runs out of sodium. Then softening stops and the bed of styrene resin must be regenerated to restore its capacity.

Backwashing is first part of this process. Flow of water through the exchanger bed is reversed. Rates of 5 to 7 gpm per sq ft for about 10 minutes will remove any dirt accumulated on top of the material and loosen, regrade it to prevent packing and channeling.

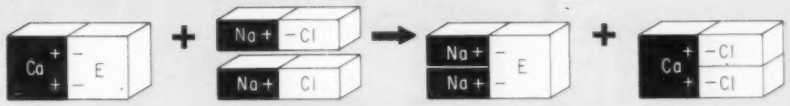
Introducing regenerant is the

Sodium-cation exchangers swap sodium ions for other metal ions



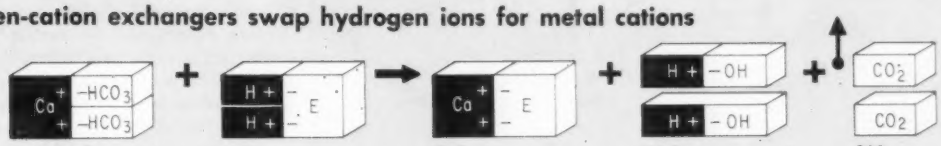
$Ca(HCO_3)_2$ Calcium bicarbonate — Na_2E Sodium-cation exchanger — CaE Calcium-cation exchanger — $2NaHCO_3$ Sodium bicarbonate

Regeneration restores capacity by replacing calcium ions with sodium



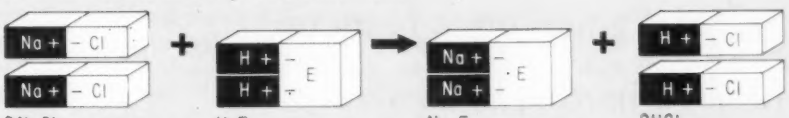
CaE Calcium-cation exchanger — $2NaCl$ Sodium chloride — Na_2E Sodium-cation exchanger — $CaCl_2$ Calcium chloride

Hydrogen-cation exchangers swap hydrogen ions for metal cations



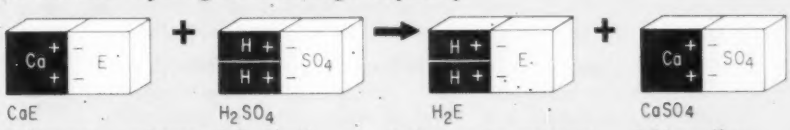
$Ca(HCO_3)_2$ Calcium bicarbonate — H_2E Hydrogen-cation exchanger — CaE Calcium-cation exchanger — $2H_2O$ Water — $2CO_2$ Carbon dioxide

Cation exchanger turns sodium chloride into hydrochloric acid



$2NaCl$ Sodium chloride — H_2E Hydrogen-cation exchanger — Na_2E Sodium-cation exchanger — $2HCl$ Hydrochloric acid

Then, regeneration with acid restores hydrogen exchange capacity



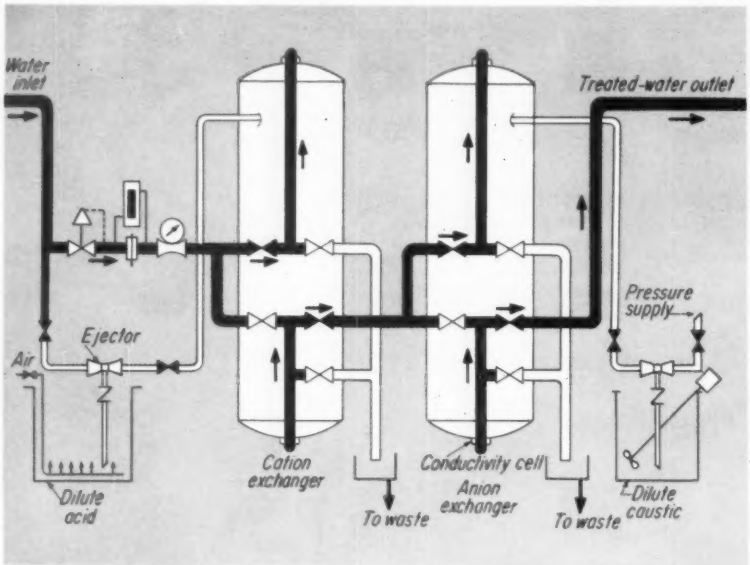
CaE Calcium-cation exchanger — H_2SO_4 Sulfuric acid — H_2E Hydrogen-cation exchanger — $CaSO_4$ Calcium sulfate

next step. A saturated-brine solution is picked up by the ejector and passed downward through the exchanger bed. This reverses the exchange reaction and sodium from the brine displaces the accumulation of calcium and magnesium on the exchanger.

Rinse water is admitted to flush out calcium, magnesium and the remaining brine. Volume of rinse water is about 25 gal per cu ft. Entire regenerating cycle takes about one hour; it can be made fully automatic by adding time-control devices. Two or more units usually operate in parallel to maintain a continuous flow of treated water. Regenerations are staggered so only one unit at a time is off the line. Since water leaving the sodium-cation exchanger has little hardness, it primarily contains sodium salts. Total solids are not reduced by sodium-exchange softening.

Now let's fill our ion exchanger with hydrogen cation material. As shown, right, calcium magnesium and sodium cations are exchanged for hydrogen ions. In this way the salts are converted into an equivalent amount of the corresponding acid. Bicarbonates, sulfates and chlorides become carbonic, sulfuric and hydrochloric acids. Water leaving the unit is a weak solution of these acids. The carbonic acid breaks up into water and CO_2 which can be expelled by aeration. Thus total dissolved solids are reduced by an amount about equal to water's original alkalinity.

Capacity of the hydrogen exchanger is restored by regeneration with sulfuric acid. Since both the regenerant and the effluent water are acid, the exchange vessel is usually lined with rubber. Piping and valves



These two exchangers demineralize water

Raw water enters hydrogen-cation exchanger through a pressure reducing valve, rate-of-flow indicator and flow totalizer. Water coming out contains dilute hydrochloric and sulfuric acids plus carbon dioxide. Anion unit then exchanges acid radicals for hydroxide ions to form water. Water quality is monitored by a conductivity instrument. With a strongly basic resin, silica and carbon dioxide are also taken out. Often a degasifier or vacuum deaerator is called on to reduce carbon-dioxide load on the anion exchanger. If weakly basic material is used, both carbon dioxide and silica pass through the system. A degasifier is then added to remove the carbon dioxide mechanically to a residual in the range of 2 to 5 ppm.

Cation and anion units team up to remove hardness, alkalinity, dissolved solids, silica from water

in contact with acid water are also rubber lined or otherwise made corrosion resistant. Stainless-steel and plastic parts are substituted wherever use of lining is found impractical.

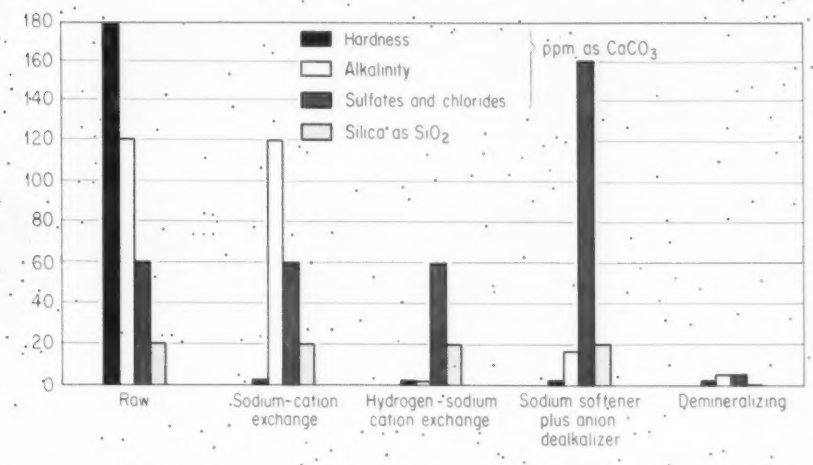
Hydrogen-cation exchanger effluent needs treatment before it's suitable for use. The pH is extremely low and it contains carbon dioxide. This is remedied by (1) removing carbon dioxide in an aerator and adding an alkali such as caustic soda or soda ash to neutralize the acid and raise pH, or (2) mixing with softened water from a sodium-cation exchanger and running the blended stream through an aerator to remove carbon dioxide. Both methods are practical, but blended-stream technique seems to be more popular. In this method, all water needed is split between hydrogen and sodium exchangers. Exact amount going through each depends upon water analysis and residual alkalinity wanted. Acid in hydrogen stream is neutralized by alkalinity in sodium stream to produce from 5 to 15 ppm alkalinity in the blend. On high-alkalinity waters residual carbon dioxide from the aerator ranges from 2 to 10 ppm.

Anion-exchange resins fall into two general categories—weak base and strong base. Chemical building-block equations, facing page, show how strongly basic exchange material picks up acid radicals and silica from a hydrogen unit, leaving essentially pure water. Weak-base exchangers don't take out carbon dioxide or silica. They remove strong acids by a process that's more like adsorption than it is ion exchange. However the end result is the same, and efficiency of strong-acid removal is far superior to that of a strong-base material doing the same job. So weak-base units are very useful when the water is high in sulfates and chlorides. In these cases they precede a strong-base unit. If silica isn't objectionable, they handle the complete job of demineralizing alone.

Chloride-anion exchange is a relatively new method of reducing alkalinity. When strong-base anion resins are regenerated with salt, they are converted to the chloride form. It's then possible to split salts by exchanging chlorides for the bicarbonate, sulfate and nitrate anions in water passing through the exchanger. By combining a sodium-cation exchanger and a chloride-anion unit, we can produce a soft low-alkalinity water without need for acid feeds or regeneration with acid. Drawbacks include the fact that sulfates and nitrates must also be exchanged. And capacity of anion material may be too low to justify its use in comparison with other methods of reducing alkalinity. Actual anion capacity is usually in range of 5 to 10 kgr per cu ft when regenerated with 3.5 to 4.0 lb per cu ft of salt. Effluent is high in chlorides, but alkalinity may be reduced 85 to 90% depending on the water analysis.

Strong-base anion resins are available as either Type I or Type II. Capacity and efficiency of Type II resins is somewhat higher than Type I. In spite of this Type I is more popular and the majority of strong-base exchangers use it. There are two main reasons for this preference: (1) Type I exchangers are usually more stable and (2) they reduce silica to

Wide variety of ion-exchange systems tailor water to fit each need



Starting with raw water, left, ion-exchange systems selectively remove all or part of the dissolved solids. Sodium-cation exchangers soften water by substituting sodium for calcium and magnesium ions. If alkalinity is too high, blend of water from hydrogen and sodium-cation exchangers produces a soft low-alkalinity water. Use of a salt-regenerated-anion dealkalizer may fit the need. Here, raw-water alkalinity is on the high side for this treatment. Alkalinity is reduced, but chlorides are increased greatly. Demineralizing removes practically all dissolved solids, but if silica removal isn't needed, use a weakly basic anion-exchange material.

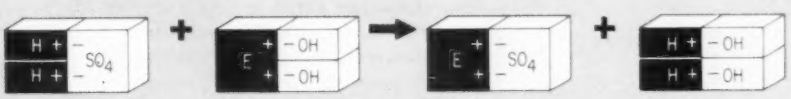
lower residuals in range of 0.02 ppm.

Porous grades of exchange resins are coming more into the picture to combat organic fouling. They hold organic matter more loosely, making it easier to remove during normal regeneration or special chemical treatment. Generally, these porous resins can be expected to give rated capacity over a longer period of time.

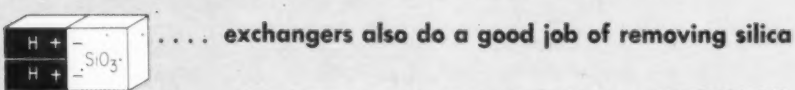
Vacuum deaerators are finding increased use in demineralizing systems. Saturating the water with air in a forced-draft aerator may cause oxidation of anion resins. Vacuum deaerator for degasification has advantage of removing oxygen in addition to the carbon dioxide.

Mixed-bed demineralizer is a single vessel containing an intimate mixture of cation- and anion-exchange material. Cation resin is the styrene-base type, and either Type I or Type II strong-base anion resins are suitable. In effect the mixed bed is equivalent to an almost infinite number of 2-step demineralizers in series. Every anion-resin bead immediately grabs the acid produced by its neighboring cation bead. Removing acid as it forms allows the reaction to go almost to completion. So mixed-bed treated water is one of our closest

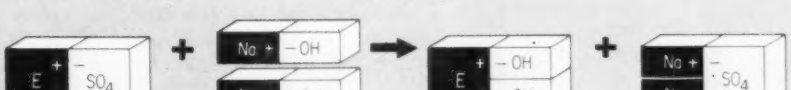
Anion exchanger takes on sulfate anion, gives up hydroxide to form water

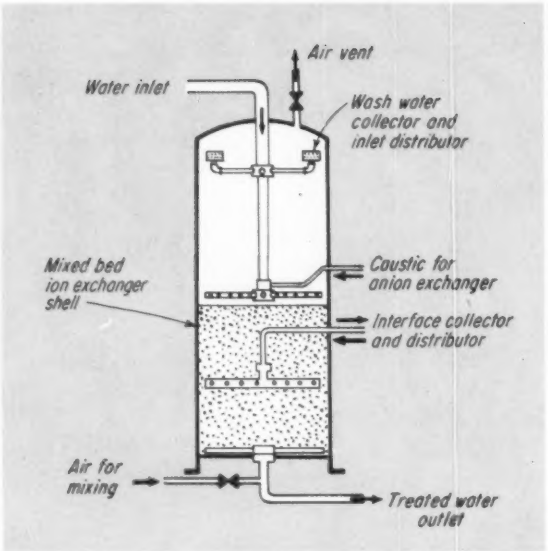


Strong-base anion .... exchangers also do a good job of removing silica

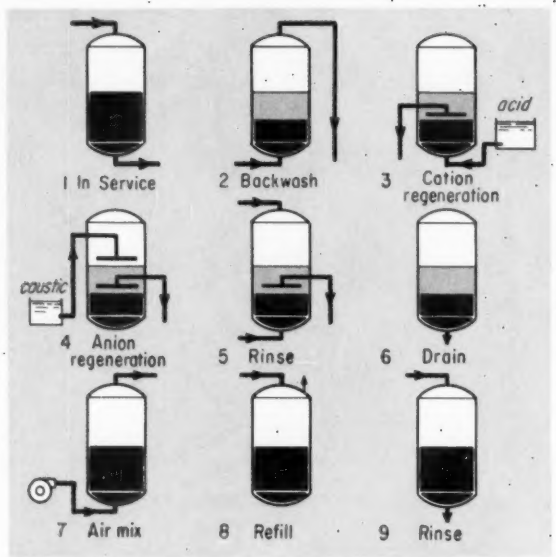


Regeneration with caustic restores capacity for hydroxide exchange





MIXED-BED DEMINERALIZER houses mixture of cation, anion exchange resins. Air for mixing enters through bottom distributor



REGENERATION of mixed bed, from initial backwash to the end of rinse and return to service, takes anywhere from 2 to 4 hours

Mixture of cation, anion resin produces top-quality water

approaches to "pure" water. Specific conductance is often in range of 0.15 micromhos or less.

Typical design, above, shows internal distributors needed to effectively operate and regenerate it. Distributor near top is for inlet flow and wash-water collection. Interface grid is used to handle regenerant flows. Bottom distributor collects treated water, distributes air for mixing and handles acid regenerant.

Regeneration first calls for backwashing to clean the beds and classify the resins. Lighter anion resin rises to the top and heavier cation resin settles to the bottom. A sharp line of demarcation is visible through a sight glass on side of the tank.

Cation resin is then regenerated with acid. Chart, above, shows acid entering bottom of unit, rising upflow through the resin and, finally, out through the interface grid. This is followed by caustic injection through the anion bed. Both beds are rinsed and the unit drained before the air mix. After resins are thoroughly mixed, unit is refilled and given a short rinse to waste before it is returned to service.

There are many variations of this procedure. Sometimes both acid and caustic are introduced simultaneously to cut overall downtime for regeneration. Depending on the sequence this operation can run 2 to 4 hr.

Now let's see how the mixed-bed process compares with a multibed system. In terms of total dissolved solids, mixed bed has an edge. Water produced is the best available. For low flows on relatively low solids and low-alkalinity water, first cost is lower. Regeneration requires less rinse water, and only a short rinse is needed to start a unit after shutdown. The mixed bed produces low-conductivity water right away.

There are disadvantages too. As you can see from the chart, regeneration is more complicated. Chemical operating cost is higher. Unless water is pretreated by a hydrogen-cation exchanger, a degasifier or vacuum deaerator can't be used effectively to remove carbon dioxide. There's also some indication from the experts that mixed bed is more susceptible to organic fouling than separate anion exchangers in multibed systems, shown at right. Some also feel the anion has lower capacity in the mixed bed.

From this comparison it looks like mixed-bed units are well-suited for plants where low first cost is important, operating cost secondary and top-quality water essential. Mixed-bed equipment also has a bright future as polishing units in both multibed systems and on condensate. Chart, right, shows today's systems.

What is conductance?

Specific conductance measures ability of a solution to conduct an electric current. Exactly defined it's the reciprocal of resistance in ohms of a 1-cm cube of liquid at a given temperature. Unit is the reciprocal ohm or mho per cm. Since conductivity of water is very small, micromhos per cm (millionth of a mho per cm) is unit commonly used. Demineralized water with about one-half ppm dissolved salt has a conductance of one micromho at room temperature. Absolutely pure water has a conductance of 0.036 micromhos.

Ten ways to demineralize water with cation, anion exchangers and degasifiers

KEY

Here are symbols for each step in treatment system

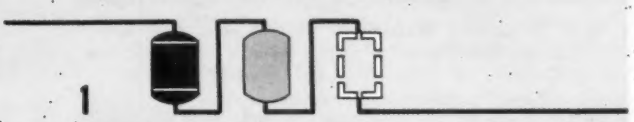
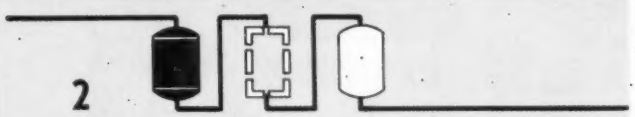
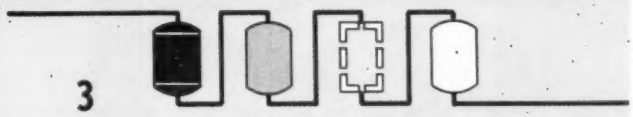
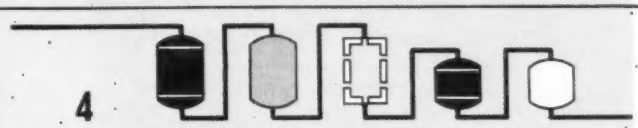
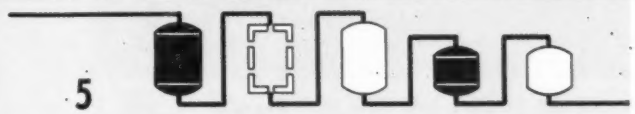
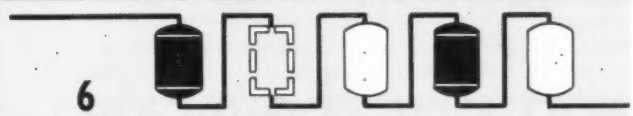
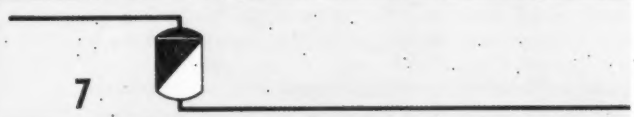
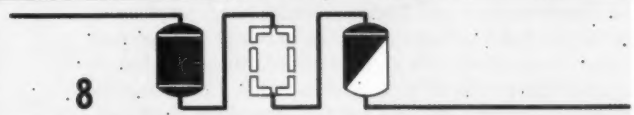
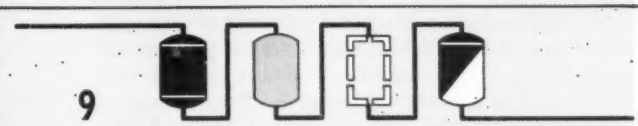
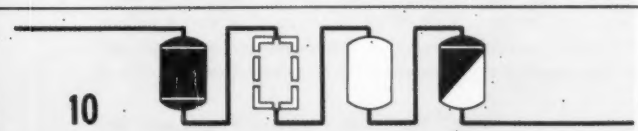
Hydrogen cation unit removes Ca, Mg and Na

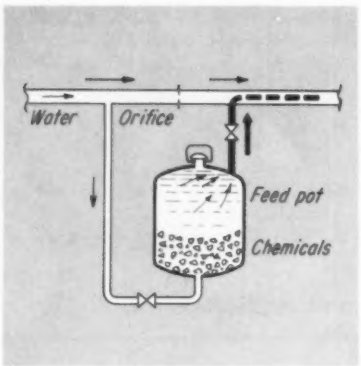
Weak-base anion unit removes Cl and SO_4 radicals

Strong-base anion unit also removes SiO_2 and CO_2

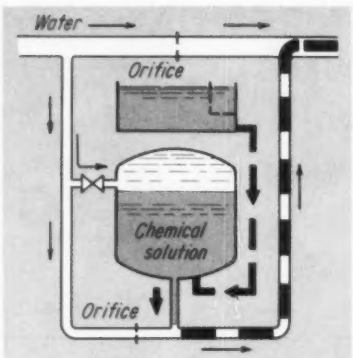
Mixed-bed unit has cation and strong-base resin mixed

Degasifier takes out CO_2, also O_2 if a vacuum type

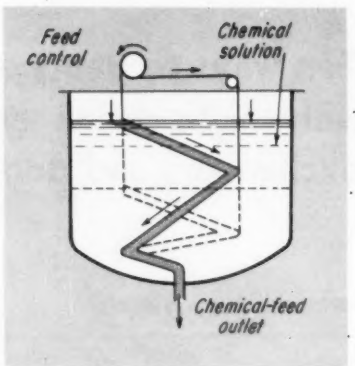
Demineralizing systems	Water quality and application
1 	Treated-water conductance ranges from 10 to 20 micromhos. Silica isn't removed. Low-cost anion-exchange material is regenerated with soda ash or caustic
2 	Silica in treated water is reduced to level of 0.02 to 0.15 ppm. Conductance ranges from 10 to 20 micromhos. Degasifier reduces CO_2 load on anion exchanger
3 	If water is high in sulfates and chlorides, use low-cost weak-base unit to handle bulk of anion load. Water quality is same as above; operating cost is lower
4 	Polishing units give conductance of 3 to 6 micromhos. Silica ranges from 0.02 to 0.15 ppm. Series regeneration of both cation, anion units cuts operating cost
5 	Use when the alkalinity is major part of anions. Polishing units regenerate infrequently. Effluent conductance is 1 to 5 micromhos with silica same as above
6 	Alternating-series hookup is flexible variation of method above. Units run in parallel for peak flows. Each pair gives service flow while other regenerates
7 	Treated-water conductance ranges from 0.15 to 1.0 micromhos with silica reduced to level of 0.02 to 0.15 ppm. Operating cost is higher than for multibed systems
8 	If alkalinity is high, use cation unit and degasifier to reduce anion load by removing CO_2. This cuts both the size and operating cost of mixed-bed exchanger
9 	When raw water is high in sulfates and chlorides, 2-step demineralizer with weak-base anion unit reduces both operating cost and size of mixed-bed exchanger
10 	Use a strong-base anion unit and degasifier if water is high in alkalinity and silica. Mixed bed then operates as polishing unit with infrequent regeneration



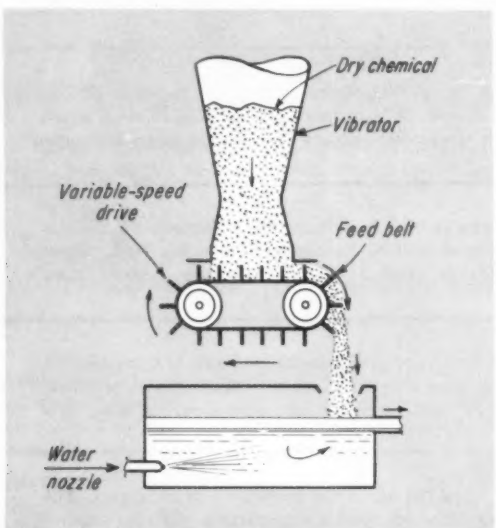
POT TYPE FEEDERS use bypass flow to dissolve chemical crystals, lumps, briquettes



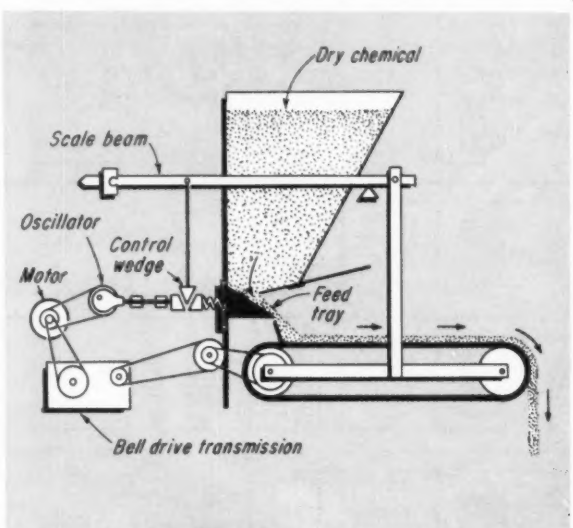
PRESSURE SOLUTION feeds discharge alum, soda ash in proportion to main flow



DECANTING FEEDER uses water meter, timer to control lowering of drawoff pipe



DRY FEED has moving belt with lugs that slice off equal volumes of chemical directly from vibrating hopper above



GRAVIMETRIC FEEDERS have three basic elements: (1) scale or weight sensing element (2) feeding mechanism and (3) controller

Feeders move wet and dry chemicals

Handling and feeding chemicals is an important part of every water-treating system. Treatment reactions must be supplied with the right amount of chemicals at the proper strength. Many feeder designs have evolved to cover each specific treatment.

Feeding equipment falls into three broad categories: wet, dry and gas. While rate of feed may be either constant or proportional, feeding chemicals in intermittent slugs is also common. Dry-chemical feeders are best suited for handling large amounts of chemical. Wet or solution feeders are more convenient and accurate for smaller quantities. Thus, selection of a specific feeder depends primarily on amount and type of chemicals used.

Pot type feeders are usually limited to feeding alum or sal-soda in either crystal or lump form. They're also called on to handle specially prepared chemical briquettes.

In use, the chemical is placed in the feeding pot where it's dissolved by water flowing from the high-pressure to low-pressure side of an orifice. Since this flow is proportional to main-line flow, amount of chemical fed is roughly proportional too. Control isn't exact because there's no way to adjust the solution rate of the chemicals.

Pressure-solution feeders aren't limited to crystalline or lump forms of chemical and feed is proportioned to flow within a reasonable degree of accuracy. An open tank is used to dissolve the chemical. Then solution is charged into bottom of pressure tank and displaced water flows out the top. Sight glass shows level of the chemical. Next, solution is fed from bottom of tank to bypass circuit.

Decanting type feeder has a swing drawoff pipe to

remove solution at desired rate. This feed is good for practically any type of solution or slurry. In proportional control the water meter actuates an adjustable timer that starts the feeder motor and lowers the drawoff pipe for a preset time interval. The feeder is usually equipped with a propellor mixer, cover and dust evacuator when handling chemicals such as lime or soda ash.

Dry-chemical feeders are classed as volumetric or gravimetric units. Volumetric type, facing page, uses a moving belt to remove chemical from a vibrating hopper. The adjustable-speed belt has lugs that deliver equal volumes of dry material. Unit is suitable for constant-rate or proportional feeding. Accuracy of any volumetric feeder depends on consistency of the material handled. If density varies so will rate of feed. Normal accuracy of volumetric dry-chemical units is in the range of 5%.

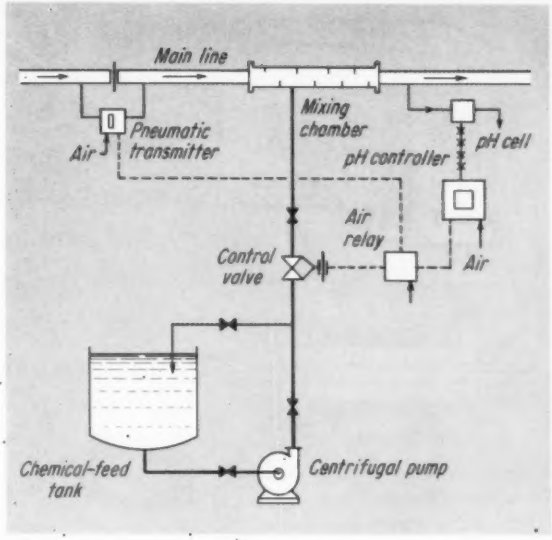
Gravimetric feeders bank on weight to measure the amount of chemical fed. Dry material drops from the hopper onto a traveling belt. Scale beam is set for a constant weight of chemical and rate of feed is varied by adjusting the speed of the belt. Total weight of the belt assembly and the chemical on it controls the amount of chemical dropped onto the belt. If weight is below set point, vibration amplitude of the feed tray increases, upping volume of chemicals fed to the belt. If weight is above set point, vibration amplitude decreases and feed to belt is cut. Accuracy of proportioning is 1 to 2%.

Pump feeding systems come in a variety of designs employing both positive displacement and centrifugal pumps. Pump feed, right, takes care of wide flow swings in the main line. Flow and pH are used as control-signal sources. Control valve on the chemical inlet line receives signals from flow transmitter and pH controller through an air relay. Mixing chamber in main line brings water and chemicals into turbulent contact.

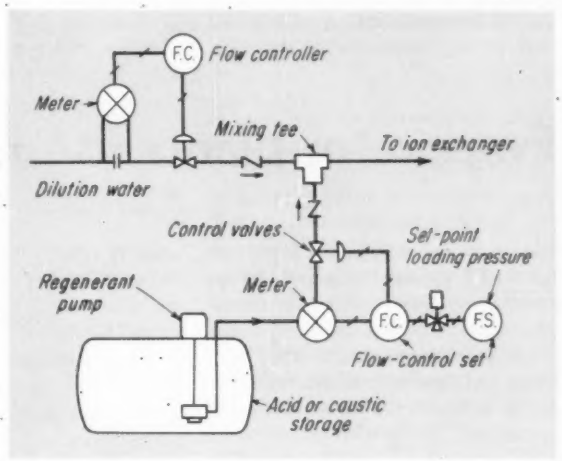
If a positive-displacement pump is called for, the arrangement changes. Here, flow transmitter controls speed of pump motor through a Thymotrol unit. The pH controller adjusts the length of pump stroke. Chemical flow is still sensitive to both of these variables.

Regenerant feeds for demineralizing systems are receiving more attention with the trend to fully automatic operation. Arrangement at right can be used for either acid or causic. In general it must deliver the correct amount of chemical, in proper concentration, in an allotted time. Pneumatic flow-rate controllers are located on both the dilution water and regenerant lines. Thus, the correct proportion of regenerant and water is continously maintained. A timer controls total volume.

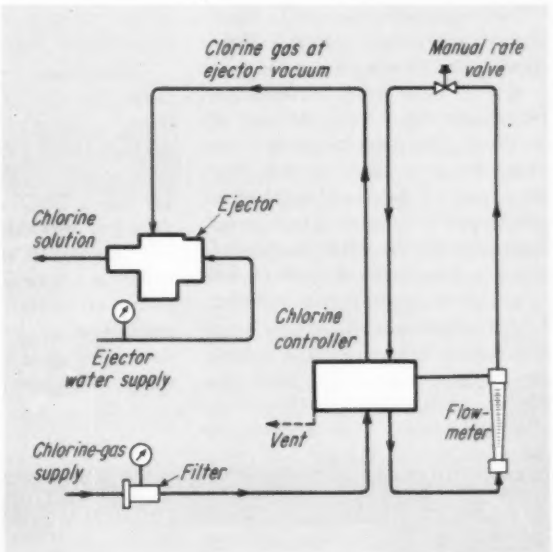
Chlorinator measures, dissolves and feeds chlorine to the water being treated. In design at right, water flows through an ejector continuously. This creates a vacuum that extends back to the chlorine controller. Flow of chlorine gas to the ejector is adjusted by the manual rate-set valve. Chlorine controller acts to keep gas flow constant for any given rate-valve setting. The chlorine flows to the ejector where it's mixed with water just before leaving the unit and discharged to the point of application.



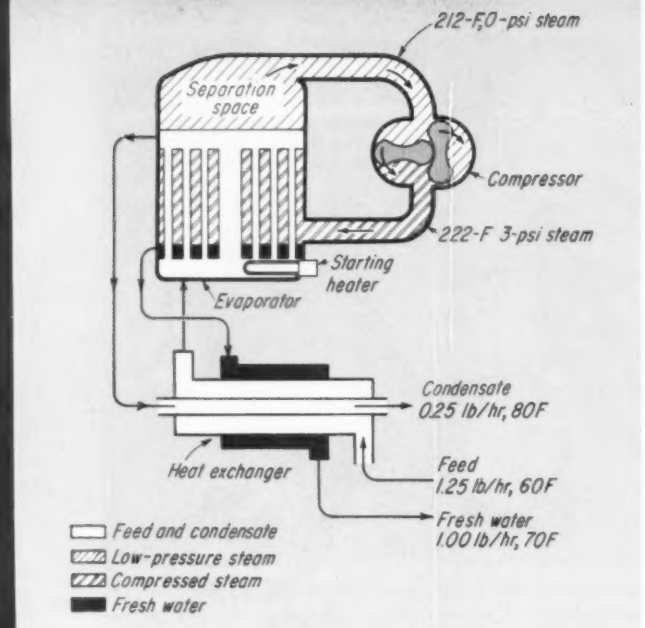
PUMP FEED SYSTEMS often use automatic pH and flow control to handle swings in main-line flow and variations in water analysis

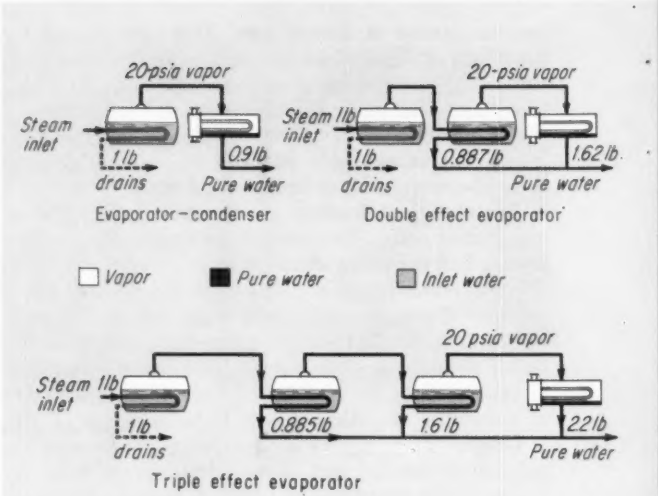


REGENERANT FEED for acid or caustic in ion-exchange systems deliver the right amounts of chemical solution at desired strength



CHLORINATOR uses water-ejector assembly to draw chlorine gas through system, mix it with water and deliver chlorine solution





VAPOR COMPRESSION distillation unit uses mechanical shaft work to heat water vapor by increasing its pressure to 3 psig

EVAPORATORS boil makeup water; resulting steam is condensed to form pure water. Increasing number of effects ups the efficiency

Evaporator plants use heat to remove solids

Dissolved and suspended solids are removed from water effectively by the purely mechanical process of vaporizing water with heat. The evaporator is simply a pressure tank filled with steam coils and a moisture separator on the outlet. Vapor is condensed in a separate heat exchanger to form pure water. Tank shell has coiled or straight-through tubes. Heating steam flows inside the coils and makeup water enters the shell.

When tubes are immersed in the incoming raw water, unit is called a submerged tube evaporator. If water is filmed over tube surfaces and flashed into vapor along the way, it's known as a film type evaporator. Another design, called a flash type evaporator, operates with its chamber under a partial vacuum. Incoming raw water is preheated and temperature is raised high enough to flash water into vapor when it enters the chamber.

Multiple-effect evaporator is an arrangement of two or more units in series. Steam produced by one evaporator is condensed in heating coils of the next lower pressure stage, and so on. Pure water from each effect flows to a common outlet header.

Single-effect evaporators are preferred for boiler-feed makeup because more water can be produced by a given amount of evaporator-tube surface. Multiple-effect plants are a must where evaporator is called on to produce potable water. Here, increased operating efficiency justifies added plant cost, and larger number of effects reduces the fuel need.

Vapor-compression evaporator consists of a boiling chamber, heat exchanger, vapor compressor and starting heater. Hot water from the heat exchanger enters the evaporator chamber where it's boiled at atmospheric pressure. Resulting steam is fed to the compressor where its pressure is raised to about 3 psig. Compressed steam or vapor flows back to the evaporator or boiling section, condenses and gives up heat to boil more water. Outgoing condensate passes through a heat exchanger to heat the incoming feed. Starting heat comes from an external source. When steam is produced, the motor- or diesel-driven compressor goes into action.

Evaporators are not without scale and corrosion problems. Depending on water analysis and type of plant, evaporator tubes may accumulate scale. This can be loosened by heating the tubes and dousing them with cold water. Some designs let the tubes expand and take on a bowed shape during operation. When shell is filled with cold water, tubes quickly straighten, helping to crack off scale. Pretreatment of evaporator feed is generally favored to minimize cleaning and improve effluent quality. Well-designed evaporators can produce vapor containing less than 0.25 ppm total dissolved solids.

In preparing this report the author had the unstinting help and cooperation of the entire water-treating industry. He particularly thanks I F Wilkes, S B Applebaum, D Miller.

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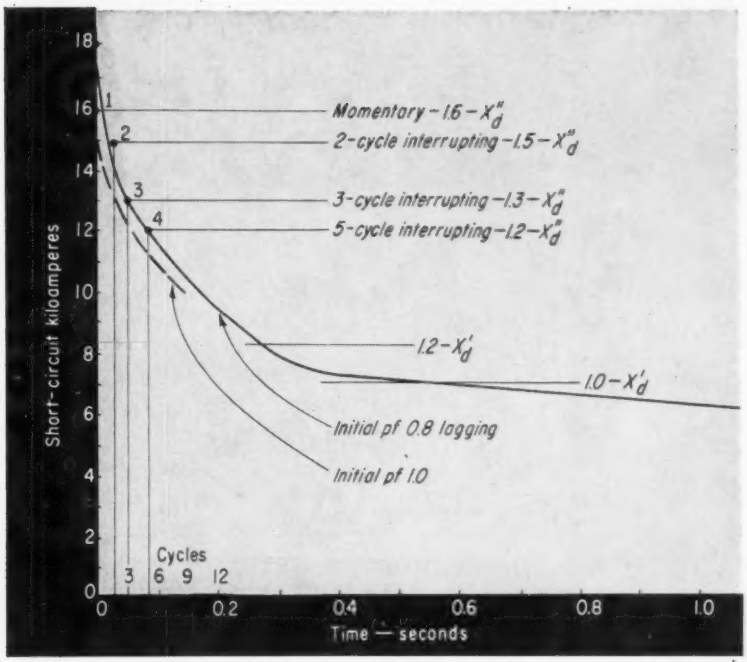
By A H KNABLE, Allis-Chalmers Manufacturing Co

When selecting circuit breakers to handle fault currents on distribution systems of 600 volts or less a different approach is needed than for high voltages. To understand why, let's see what happens on a l-v fault

How to calculate fault current in l-v systems



CURRENT DECAY from a 1500-kva generator with a fault on the generator's bus, where X''_d=18%, X'_d=26%. The values for 1.0—X'_d and 1.2—X'_d are shown for comparison only

$$\text{Normal current} = \frac{1500 \text{ kva}}{0.48 \text{ kv}\sqrt{3}} \doteq 1800 \text{ amp}$$

$$\text{Short-circuit current} = \frac{e}{X''_d} = \frac{1.0}{0.18} = 5.55 \text{ pu amp}$$

Simplified calculations—

Point *1*: Momentary asymmetrical current = 5.55 x 1.6 x 1800 = 16,000 amp
Point *2*: Interrupting asymmetrical current = 5.55 x 1.5 x 1800 = 15,000 amp
Point *3*: Interrupting asymmetrical current = 5.55 x 1.3 x 1800 = 13,000 amp
Point *4*: Interrupting asymmetrical current = 5.55 x 1.2 x 1800 = 12,000 amp

Two types of short-circuit calculations are required for low-voltage systems, depending upon the nature of the problem. (See POWER's Special Report, *Electrical Distribution Protection*, June 1958.)

If the breaker rating is to be determined, the standard (NEMA *Standards Publication 213—1957 Part 3*) momentary-duty method of calculation with synchronous and induction machines represented by subtransient reactance (X''_d) is followed. However, the low-voltage multiplier of 1.25 is used instead of 1.6 commonly called for in high-voltage systems. Here are the reasons:

(1) The average asymmetrical value of the three phases is the reference value in low-voltage circuit-breaker testing and rating.

(2) The (X/R) ratio in low-voltage systems is inherently small, permitting rapid decay of current.

On the other hand, if relay settings are to be determined, the 1.25 multiplier is misleading, particularly where there is low-voltage generation. Low-voltage generators have a decay rate much like the higher-voltage generators, and no one value will define this rate. Furthermore, the sustained fault condition is often required in relay application work.

Conventional momentary-duty calculation employing the 1.25 multiplier is straightforward for circuit-breaker application. Only the fault-

current analysis for relay application need be considered further.

Curves resulting from detailed calculations are shown on p 105. For comparison, typical multiplying factors were used to establish specific points on the graph. The comparison between simplified and detailed calculations brings out:

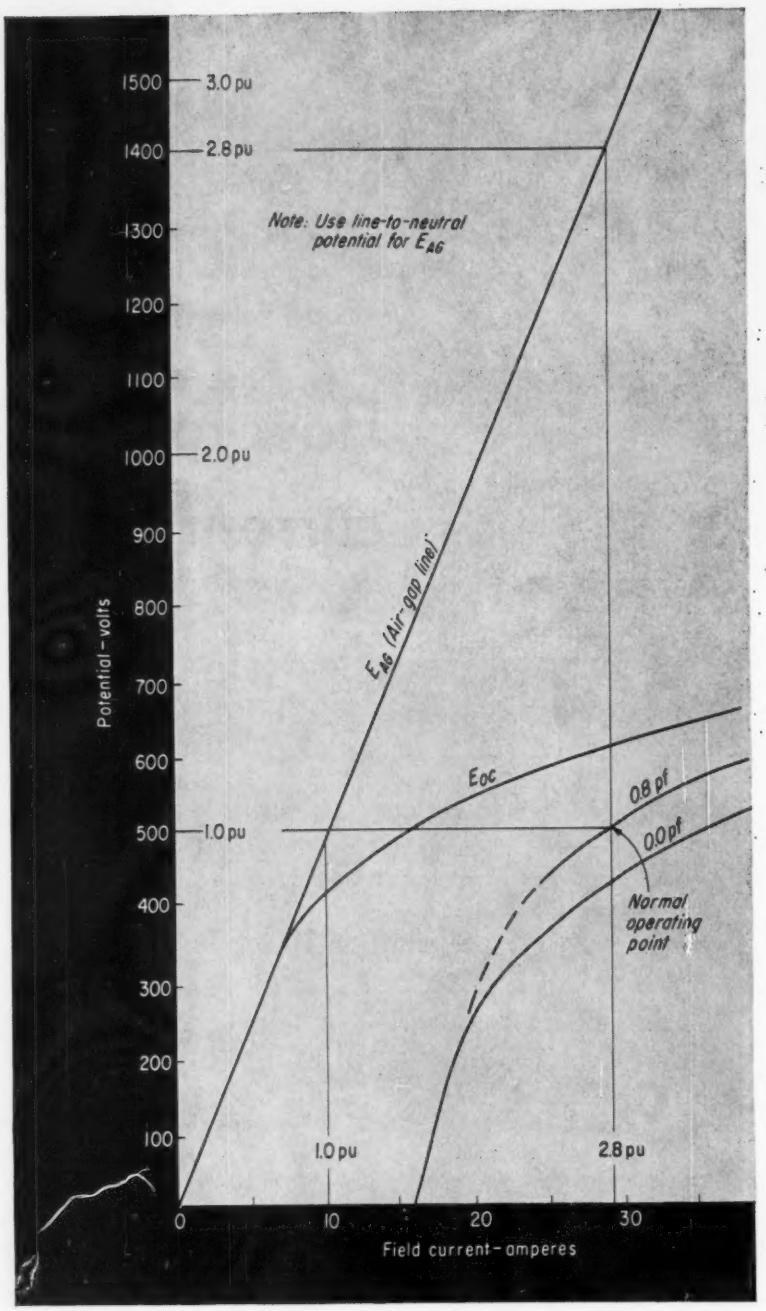
(1) The generator reactance used should be subtransient, even during the transient period, because this reactance results in points *1*, *2*, *3* and *4* (these points are found by simplified calculations) falling on the curves obtained by detailed calculations.

(2) The solid curve begins at 18,000 amp, which is 200 amp above the momentary-duty calculation point *1*. This difference results from the fact that when the generator is operating at 0.8 pf (lag) the voltage behind subtransient reactance can no longer be assumed similar to 1.0 per unit (pu) in magnitude as it was for unity pf. This voltage becomes in the order of 15% greater, or 1.15 pu, (1.15 x 16,000 amp or about 18,000 amp), as depicted by the solid curve on the short-circuit current graph.

Note that when using an ac network calculator for short-circuit calculations this increase in voltage is taken care of automatically, but when longhand calculations are performed this is sometimes overlooked. Fortunately, the difference is usually not too great.

We've only considered the transient period of fault. Now, let's look at the sustained-fault calculations.

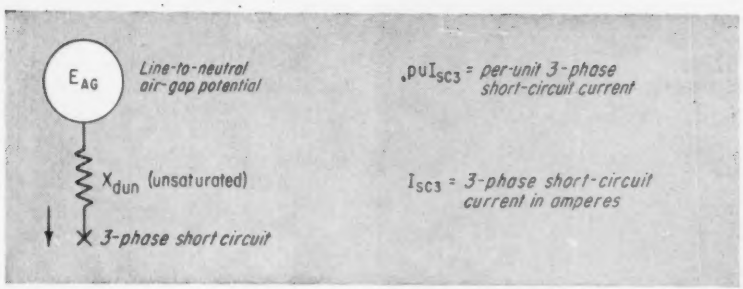
Time settings. When relay time settings extend into a period of many seconds the conventional fault-current calculations of momentary and interrupting duty become invalid. Motors fade out of the picture completely, and generators have to be represented by the steady-state synchronous reactance when such long-time settings are considered. In order to make a reliable sustained-fault calculation there are two things that have to be known: (1) The unsaturated synchronous-reactance magnitude of the generator. (2) The linear generator-excitation voltage E_f behind the synchronous reactance.



CHARACTERISTICS for 1000-kva generator. Generator data: 500 volts line-to-line rated voltage; 1150 amp rated current; 28 amp normal field current, or 2.8 pu; unsaturated X_d = 120%; X''_d = 20%; X'_d = 30%; X'_2 approx. equals X''_d; X_{2n} = 40%

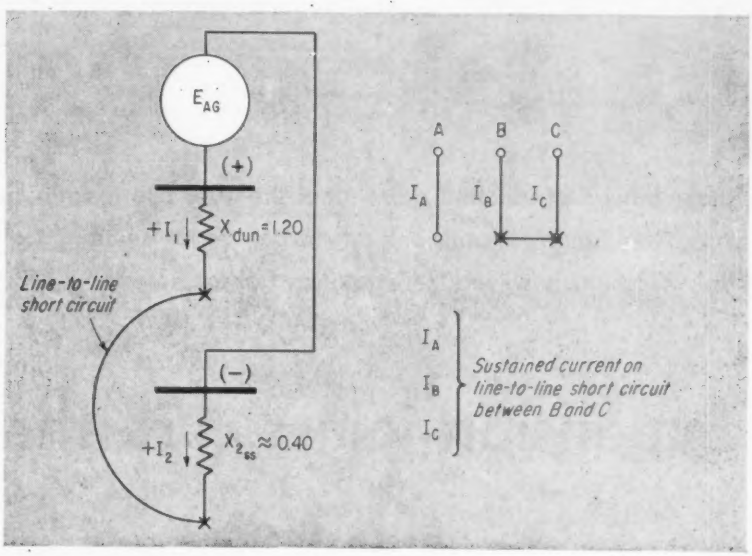
Examining these two factors we will discover that:

(1) Although the saturated synchronous reactance is generally 100% —the condition existing during normal loading—the unsaturated synchronous reactance is, more often than not, greater than 100%. Typical values are in the order of 125% for salient-pole (slow-speed) generators and 120% for round-rotor (high-speed) turbine-generators. Distin-



THREE-PHASE SHORT CIRCUIT at terminals of generator with characteristics given on p 106. The sustained short-circuit current (value after first few seconds) is:

$$\text{pu } I_{SCs} = \frac{E_{AG}}{X_{dUN}} = \frac{2.8}{1.2} = 2.33 \qquad I_{SCs} = 2.33 \times 1150 = 2680 \text{ amp}$$



LINE-TO-LINE SHORT CIRCUIT at generator's terminals, characteristics given on p 106. The sustained short-circuit current for each phase is:

$$\text{pu } I_1 = \frac{E_{AG}}{X_{dUN} + X_{2ss}} = \frac{2.8}{1.20 + 0.40} = \frac{2.8}{1.60} = 1.75$$

$I_a = -I_1\ I_A = I_1 + I_2 = 0 \qquad I_B = -j\sqrt{3}\ I_1 = -j\sqrt{3} \times 1.75 = -j3.03$ pu
$I_C = +j3.03$; the conjugate of I_B). $I_C = -I_B = 3.03 \times 1150 = 3480$ amp

guishing between saturated and unsaturated synchronous reactance is important. During faults the highly lagging stator current creates an mmf that opposes the field-current mmf, which leaves a resultant flux insufficient to saturate the iron. This, in itself, implies that the fault current should be relatively low in contrast to the saturated synchronous-reactance condition. However, it is the other change produced by this lagging stator fault current, the transition from the nonlinear (saturated knee characteristic) to the linear (unsaturated) relationship between generator excitation voltage E_f and field current i, that creates a relatively large fault current. Because of this linearity, the increase in excitation voltage greatly exceeds the increase in the unsaturated synchronous reactance, and a high fault current results.

(2) When the generator operates at nameplate rating the excitation (field current) is set at a value that yields an operating terminal voltage of 100%. Though the terminal voltage before fault is only at 100%, the generator excitation $E_f = f(i)$ during fault is, because of linearity, at a value considerably higher than 100%, generally between 250 and 300%. Since the terminology of either percent or pu is used, the 100% reference point must be defined. The 100% field current and 100% generator excitation voltages are simultaneously defined when the field current is at a value that creates an air-gap excitation voltage of magnitude equal to rated terminal voltage. Refer to graph, p 106.

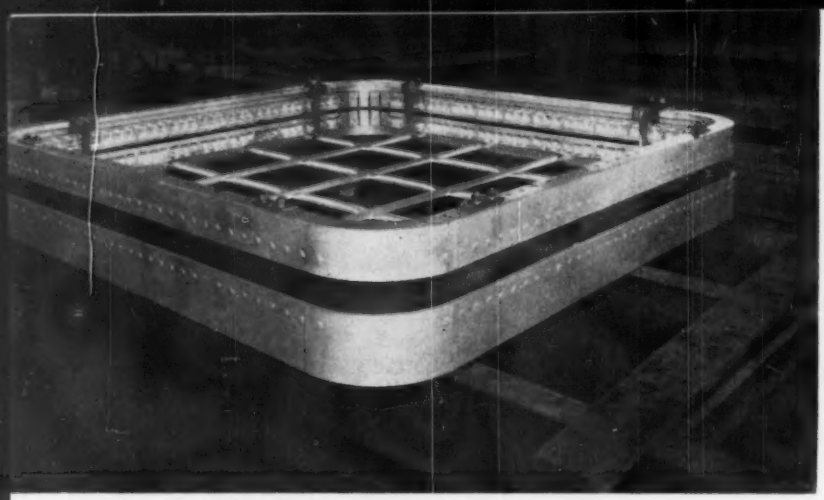
From this it follows that an E_f of 250 to 300% implies that there is 2.5 to 3.0 times rated terminal voltage behind the unsaturated synchronous reactance.

One additional point should be mentioned. Most generators have automatic regulators that will drive the excitation voltage up to the ceiling value which is, in general, 133% above normal. This means the E_f to use for a sustained fault analysis is (2.5 x 1.33) 3.3 to (3.0 x 1.33) 4.0 times rated terminal voltage.

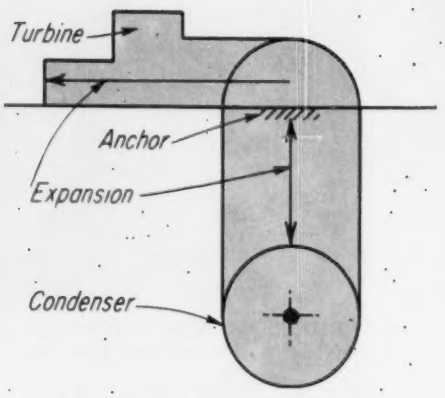
In the event that a generator has nonautomatic excitation control and is feeding a capacitive load when a short circuit occurs at the generator terminals the low excitation setting might result in a case where the fault current is less than the normal load current.

Impedance of 125%, keep in mind, still implies that it takes 125% of rated voltage to circulate rated current. The false first impression of the fault current being less than rated value because the unsaturated impedance is greater than 100%, should be replaced by the fact that the rated-pu voltage used is not 100%, but rather in the order of 300%. For normal operation the 100% (saturated) reactance requires 100% *terminal* voltage to circulate rated current.

Simple graphical analysis is shown on p 106. The sample calculations, above, employ the data of this graph. Note that the sustained-fault current for a line-to-line short circuit is greater than for a 3-phase short circuit. Of course this is not true during the first instant when the fault occurs.



BELT TYPE EXPANSION JOINT assembled for shipment and ready for installation. These joints can absorb up to 1 in. axial and ½ in. lateral movement between elements



1 Turbine and condenser expand independently as their temperatures change

By W R STEUR, Associate, Sargent & Lundy

Many factors important to reliable power production don't meet the eye, are hidden by massive construction work. Example: Small expansions of large metal sections can wreck a turbine. To see how this problem is solved, let's take a look at how . . .

Expansion joints cure the

Expansion at the turbine-exhaust condenser-inlet joint has **always** raised a problem for the power-plant designer. Despite small dimensional changes, heavy sections can produce enormous reactions.

Expansion causes. Fairly wide changes in temperature, even at the moderate exhaust level, cause dimensional variations. Exhaust temperature depends on exhaust pressure which varies with turbine load, circulating-water temperature and air leakage. Over a year, exhaust pressure may vary from 0.5 to as high as 4.0 in. Hg. This makes the temperature vary as much as 66 F.

Operating difficulties can cause even wider changes. Without a low-vacuum trip, a turbine may go noncondensing when the condenser loses its vacuum, and exhaust steam will rise above 212 F.

Running a turbine at about rated speed with no load gradually raises exhaust temperature because the limited steam flow must carry away the windage energy generated by the large exhaust blades. Some turbines have low-pressure section cooling sprays to control the temperature.

For supercritical turbines, starting procedures bypass steam into the condenser at about 250 F, making joint expansion more acute.

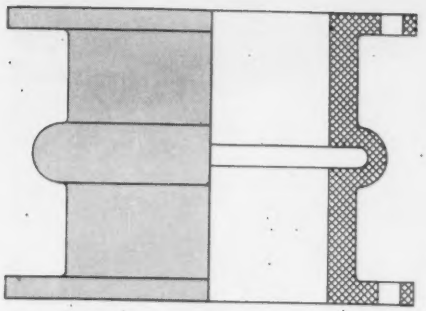
Expansion direction. Anchoring condensing turbines on their exhaust center lines lets them expand toward the high-temperature governor end, Fig. 1. The condenser has either bowed tubes or a shell expansion joint to allow for its own internal axial changes, shown by the dot in Fig. 1. The small vertical expansions must be accommodated at the turbine-condenser joint.

The vertical expansion affects the turbine primarily; twisting its frame or moving its bearing pedestals may reduce the internal clearances below the allowed tolerances. On the other hand, slight deflections ordinarily have no important effect on the condenser.

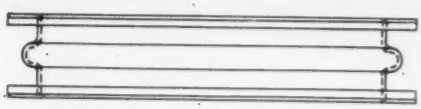
The expansion problem can be complicated by other loads imposed on the condenser. For instance, a condenser with two 36-in. circulating-water connections may have a system-friction head of 25 ft water. Even though the nozzles may be symmetrically opposite each other on the waterbox to cancel the static pressure, the condenser internal pressure drop creates a load of 11,000 lb. Applying this load 10 or 15 ft below and away from the turbine-shaft center line gives it a large moment.

Joint types. One of the first methods (over 40-years old) to care for expansion, and still used on small units, hangs the condenser on the turbine-exhaust flange. Obviously, the flange must be able to carry the condenser weight and reactions from

Expansion joints must seal tightly, have long life and be easy to inspect and maintain

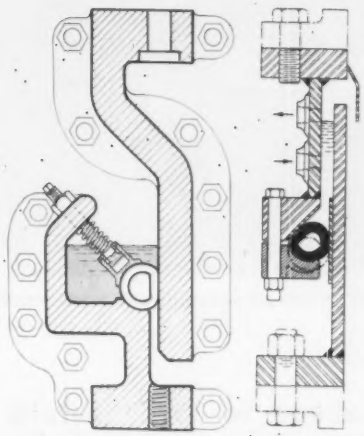


2 Spool type rubber expansion joint used for small turbines can be metal reinforced

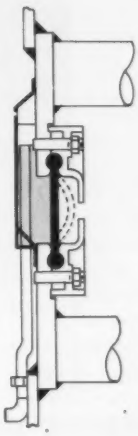


3 Copper expansion joint used on medium-sized units has cast- or forged-steel flanges

4 Omega expansion joint may be of copper; usually stainless steel for the big units



5 Phillips joints use rubber hose submerged in water for sealing; *left*—seal applied on external side, *right*—seal applied on inner side of condenser



6 Belt type joint can be submerged in condensate to insure tight seal, protect rubber against oil, extend belt life

station-designer's headache

condenser piping must be properly cared for. This may be achieved by providing heavy braces or guide keys under the waterboxes.

When the condenser can't be hung on the exhaust, spring supports may be used. Piping reactions must again be provided for, but the springs must be carefully designed. Unfortunately, spring settings can only be made for one operating condition and cannot be correct for others, such as running on half a condenser.

Screws or hydraulic jacks must take the weight of the flooded condenser. Piers and pads to support the springs and jacks often add to the congestion beneath the condenser.

A third method uses an expansion joint between turbine exhaust and condenser-steam inlet. The condenser may be bolted down so no piping reactions can affect the turbine. The expansion joint can accommodate larger vertical movements of the connection between the turbine and the condenser.

With the expansion joint the vacuum load acts on the turbine-exhaust flange. The turbine is designed to take this load. The foundation must also carry this vacuum load and keep deflections within the turbine's allowable limits. Usually this does not call for a heavier foundation; proper distribution of the mass around the turbine-exhaust end gives the section moduli needed for small deflections.

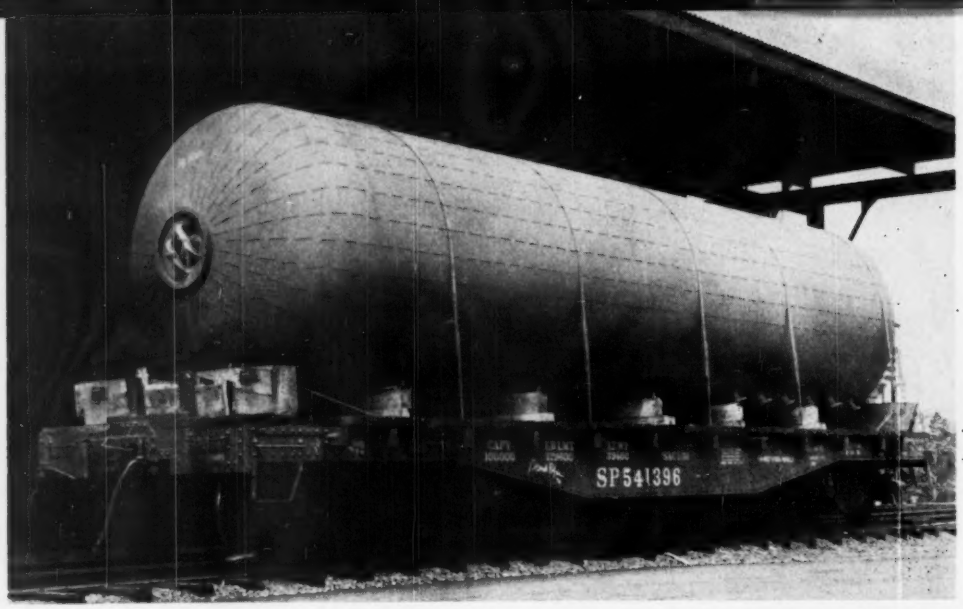
Several types of expansion joints can be used. Early joints were simple U-shaped affairs clamped to flanges on turbine exhaust and condenser inlet. They were made of reinforced rubber, Fig. 2, or formed copper, Fig. 3. Rubber joints were particularly successful, some having served for many years. They are still used today on some of the smaller units with small deflections.

The omega joint is a variation of the original copper joint, Fig. 4. This type has been used on larger machines, but is usually made of stainless steel to avoid fatigue-failure shortcomings of copper.

The Phillips joint, brought out about 1923, made a fundamental variation in joint design, Fig. 5. It does not use a continuous membrane to seal against vacuum. Instead, a hose section laid in a trough is sealed with condensate, allowing the joint to take very large movements. The small amount of sealing condensate reenters the cycle by leaking past the hose into the condenser. The internal Phillips joint, Fig. 5, *right*, became available in 1958, with the hose and clamping bars installed from inside the exhaust space.

Variations of the belt type expansion joint have been used since the early 1920's, Fig. 6. The flexing member is a builtup rubber belt, with

(*Continued on page* 168)



EXPANSION TANK, 20,000 gal capacity, 9 x 39 ft and weighing 27 tons is now mounted on top of the boilerhouse

Behr-Manning plans ahead to 1975, installs a 132 million Btu per hr unit to . . .

Get top performance from h-p hot water

By R N CLARKE
and T J McMAHON*

Planning ahead to take advantage of an expanding market isn't a particularly risky business when economic conditions are on the upswing. But in uncertain times plant expansion requires a fairish amount of faith in back of required capital expenditure.

Believing that the much-talked-about "recession" would peter out even before the high priests of pessimism could make a case, our Troy, N. Y. plant, makers of coated abrasive and pressure-sensitive tapes, gave the green light to capacity-increase plans that anticipated our needs as far ahead as 1975.

Result is one of country's largest high-pressure hot-water systems. Recently put on stream, our new Supertherm equipment delivers 115,000,000 Btu per hr, has an overload rating of 132,000,000 for process and space heating. Delivering water at 150 psi, 365 F, the new plant linked up with existing units of much more moderate performance: three converted steam boilers, each with 40,000,000 Btu per hr capacity. New system's pumps boost pressure to 250 psi to guard against drop to 150-psi flashover point in the return lines.

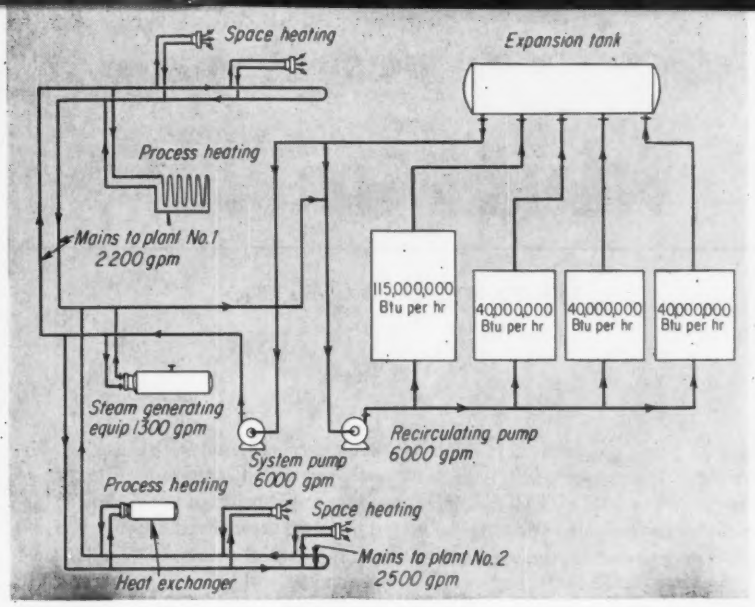
Existing boilers were coal burning, so we modernized with a completely new coal-handling system. A double-track conveyor takes coal 100 ft from hopper cars to a bucket elevator that (1) discharges to a horizontal screw conveyor running to our new 250-ton bunker (2) delivers to three existing 50-ton bunkers in the old boilerhouse or (3) takes coal to outside storage that accommodates 4000 tons—more than 2½ months' supply. System can unload and convey 75 tons per hr.

In the boilerhouse, 100-hp motors drive two pulverizers serving new boiler's four flare type burners. Estimated peak consumption is 5.5 tons per hr. Each pulverizer can supply 70% of this, so we have ample reserve.

Ash is picked up in main furnace section from ash hopper and in convection section by a regular dust hopper. Flyash goes to a tubular dust collector. A 9-ton-per-hr steam-vacuum system removes and delivers ash to an outdoor 25-ton silo equipped with a spray system for dust control. Air flow is governed by pneumatic combustion controls; firing rate is controlled at coal feeders on basis of Btu output. Air flow and Btu output are recorded on a single chart. Combustion controls, which maintain fixed outlet temperature and pressure, include an automatic furnace purge that functions before a unit can be refired.

Water enters boiler's convection section (having 5 miles of 1½-in. tubing) for preheating, passes to

*Supervisor of staff engineering and power plant engineer, respectively, Behr-Manning Company, Troy, New York



SCHEMATIC arrangement of system which now has peak capacity of 252 million Btu per hr

waterwall section (2 miles of tubing) where its temperature is upped to 365 F. Two 3000-gpm pumps, with 100-hp motor drives, provide boiler circulation. A third pump of similar capacity is held as a spare.

From the boiler, water goes to the 20,000-gal expansion tank atop the 72-ft high boilerhouse. The tank, an ASME *Code* vessel built for 300 psi, weighs 27 tons empty, is 9 ft in diameter and 39 ft long. System operates with about 12,000 gal in the tank, or 60% of capacity. Tank has liquid-level controls that signal water level and, interlocked with the boiler controls, shut off fuel supply if water level approaches a danger point.

Three cast-steel centrifugal pumps, 2000 gpm with 150-hp motor drives, circulate water through system and main heat exchangers. Latter produce 12,000 lb steam per hr for process plus steam needed for ash-removal system. Entire system holds 70,000 gal of water in some 20 miles of piping ranging in diameter from 1 to 10 in. Direct hot water through 330 unit heaters handles space heating. In addition, 57 secondary heat exchangers generate steam or heat water or oil for temperature needs from 120 to 320 F. All drying ovens are heated by feeding h-t water through a series of air-blast coils.

Big reason for expanding existing system is its numerous advantages over steam. First, there's an estimated 15 to 20% saving in operating cost. Next, perhaps, is simplicity. Centralized control in the boilerhouse frees us from reliance on (and maintenance of) traps and pumps scattered throughout the plant. Water-treatment need is slight because makeup is 0.1% instead of 35 to 50%. With an oxygen-free system we have no return-line corrosion troubles. Not an inch of original system piping was replaced because of corrosion or erosion during its 18-yr service.

In a closed circuit such as ours, water level remains constant. Large thermal reservoir of water in piping reduces boiler shock; system itself buffers sudden high demands. At 365 F, each cu ft of pipe in a water system carries 18,610 Btu as compared to 434 Btu for a 150 psi steam circuit—a 43:1 ratio. Temperature drop of our supply at its longest run is too small to measure.

There are problems peculiar to the Supertherm system, but they haven't proved troublesome. Valves and packing have to be kept tight, and initial heatup and cooling time are longer.

System performance has fully justified the capital investment and is bearing out our expectation of low operating and maintenance costs.

New power plant equipment

Behr-Manning Co, Troy, N. Y.

H-t water boiler, 1 — LaMont type, International Boiler Works
115,000,000 Btu per hr continuous capacity. (7 miles of 1½ in. tubes)
132,000,000 Btu overload rating

Expansion tank, 1 — Riley Stoker Corp
20,000 gal capacity, cylindrical, 9 x 39 ft, 27 tons

Air heater, 1 — The Air Preheater Corp
Ljungstrom regenerative

Pulverizers, 2 — Riley Stoker Corp
Firing equipment includes steam-atomizing oil burners and gas burners

F-d fan, 1 — Sturtevant Div, Westinghouse Electric Corp

I-d fan, 1 — Prat-Daniel Corp

Dust collector, 1 tubular — Prat-Daniel Corp

Soot blowers — Diamond Power Specialty Corp

Combustion controls, pneumatic — Bailey Meter Co

Water-level controls — Yarnall-Waring Co

Circulating pumps, 3 — Ingersoll-Rand Co

Circulating-pump motors, 3 — General Electric Co

Coal-handling system — Gifford-Wood Co
Complete 75-ton-per-hr system: 250-ton bunker, double-track conveyor bucket elevator, screw conveyor and all necessary motors

Ash-handling system — United Conveyor Corp
Steam-vacuum, 9-ton-per-hr capacity, ash hopper and 25-ton capacity silo

Heat exchangers, 2 — Patterson-Kelley Co, Inc.
Main steam generators, 1350 gpm h-t water supply produces 12,000 lb steam per hr at 100 psi

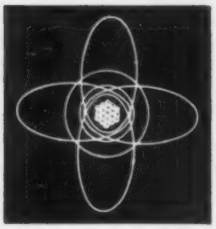
Heat-exchanger pump — Ingersoll-Rand Co
1350 gpm, 150-ft head

Heat-exchanger pump motor, 60 hp — General Electric Co

Cooling tower — Marley Co
Doubleflow, complete with motor, belt drive and fan guard

System designer — Behr-Manning Co

Consulting engineers — J O Ross



Nuclear notes

By B G A SKROTZKI, Associate Editor

Burnup of fuels still poses the biggest problem in achieving economical nuclear power. Geneva-conference papers show that reactors using metallic-uranium fuel expect to produce 3000 mwd per ton, while those using uranium oxide promise to develop 10,000 mwd per ton. Small samples of the oxide in test reactors have lived through 25,000 mwd per ton. These performances compare to the total potential energy of 857,000 mwd in each ton of uranium. Thus the best performance in sight will burn up less than 1.2% of the fuel and then need reprocessing. It's the reprocessing and not the uranium first cost that hurts.

Estimated ore reserves in South Africa, Canada, U.S.A. and France are placed at 2 million tons of uranium. What we know of geological formations, and based on the experience of the last 10 years, leads the experts to think that another 2 million tons will be uncovered. Guessing that the U.S.S.R., Red China and other iron-curtain countries have proportionate deposits makes it possible that world reserves run about 10 million tons of uranium in high-grade ores (0.25%). Uranium in lower concentrations held by shales and phosphorites is estimated as being practically unlimited, but costly to break out. Total of 10 million tons uranium reserve at 100% burnup equals about 10 times the world's estimated coal reserve.

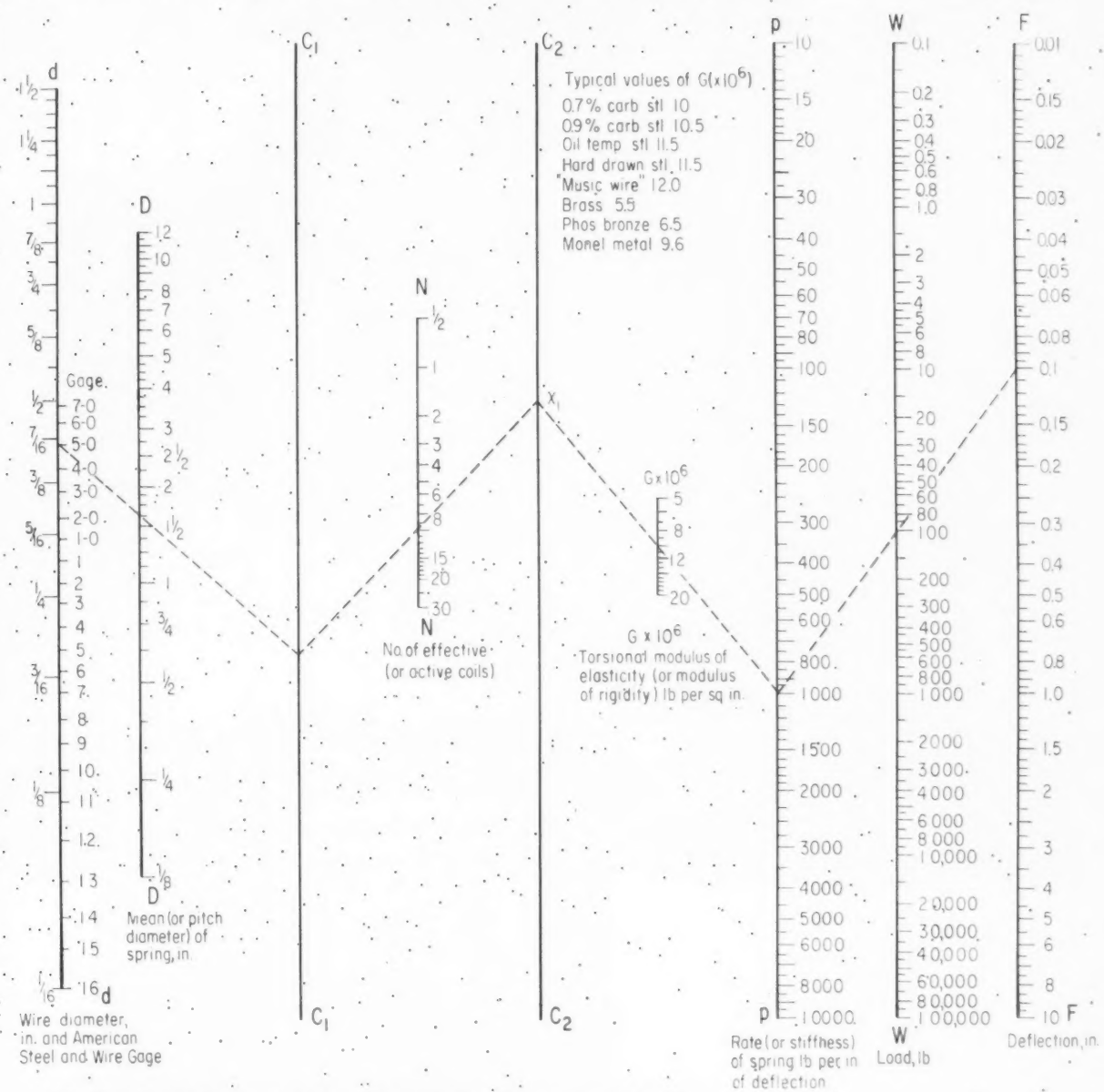
Critical assembly of Liquid Metal Fuel Reactor (LMFR) built and operated by Babcock & Wilcox Co at Lynchburg, Va., doesn't contain any liquid metal. The assembly consists of a "pile" of graphite and bismuth bars in an octagon 8-ft high and over 9 ft across. For fuels, the assembly uses enriched uranium-aluminum alloy strips fastened to bismuth bars with plastic adhesives. The subassemblies hold these bars in graphite channels. One subassembly can be changed without disturbing any of the others. Brookhaven National Laboratory first developed the reactor idea which will use uranium dissolved in molten bismuth.

86 proposals from 32 firms were handed the AEC in response to its invitation issued last September to study three types of reactors. The architect-engineering firms would make preliminary design and engineering studies and cost estimates for one of the specified reactors: (1) boiling water (2) pressurized water (3) organic cooled. A contractor selector board at the AEC's Idaho Operations Office will award a cost-plus-fixed-fee contract to three of the firms, each to make one of the studies. The studies will explore all possibilities to find the most economical plant that could be built of each type for a construction start by July 1960, anywhere in the U.S.A. or abroad.

Atomic plant speedup program proposed by General Electric Co would place twenty-five 5-mw boiling-water reactor plants throughout the U.S.A. under the ownership of local electric utilities. Other manufacturers would be expected to produce like numbers of their reactors for utility purchase and operation. GE estimates that they could have 25 of their reactor plants mass-produced for about $800 per kw. First plant of this program could be running by end of 1960 and the following ones at a rate of one to two a month. Plan would train plant personnel in supervising operation and maintenance, making them ready for developmental and economic plants expected to be ready in 1965 and 1970. Larger developmental plants would produce power for about 8½ mills per kwhr, later "target" plants would generate at about 6½ mills per kwhr. Utilities seem to be listening favorably.

Power's data sheet

No. 316



Helical springs made of round wire or rod—2

This second of two *Data Sheets* figures the stiffness of springs calculated from:

$$p = W/F = Gd^4/8ND^3$$

where p = spring stiffness, lb per in. of deflection; W = applied load, lb; F = total deflection, in.; G = torsional modulus of elasticity, lb per sq in.; d = wire or rod diameter, in. (or gage); N = number of effective coils; D = mean diameter of spring, in.

For compression springs with closed end coils, N is two less than the apparent number of coils. For good practice keep D/d greater than three. Use *Data Sheet* No. 315, (POWER, Nov 1958, p 101) to check on spring fiber stress.

Example: For a spring with G = 10 million lb per sq in., p = 1000 lb per in., d = 5-0 gage, D = 1⅝ in., find number of effective coils needed and the deflection when supporting a load of 100 lb.

Join 1000 on p scale to 10 on G scale; project to find x_1 on C_2 scale. Join 5-0 gage on d scale to 1⅝ in. on D scale, project to find x_2 on C_1 scale. Join x_2 to x_1 to find 10 on N scale. Next join 1000 on p scale to 100 on W scale to find F of 0.1 in.

J F WATERS, *Westerham, Kent, England*

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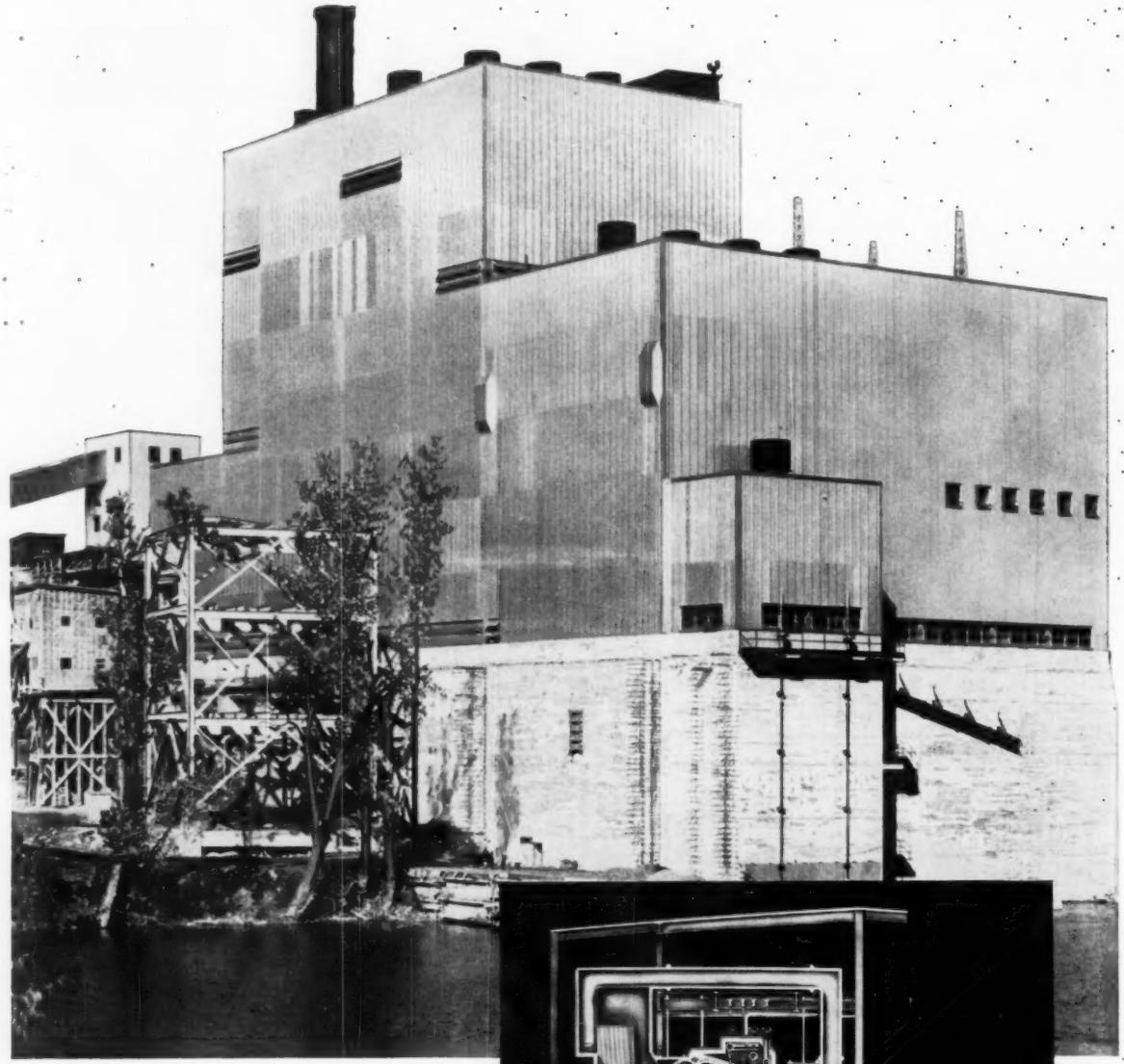

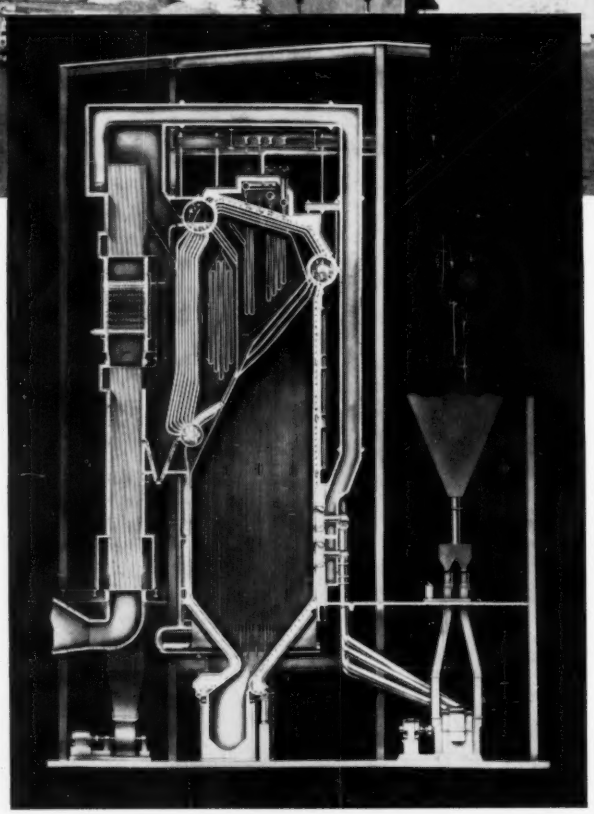

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Sanderson & Porter Engineers

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Today, Riley designs incorporate outstanding characteristics which meet the exacting requirements of the modern power plant. We are confident that it will pay you to investigate modern Riley designs when you are considering the installation of additional steam generating equipment. Riley engineers will gladly call on you.

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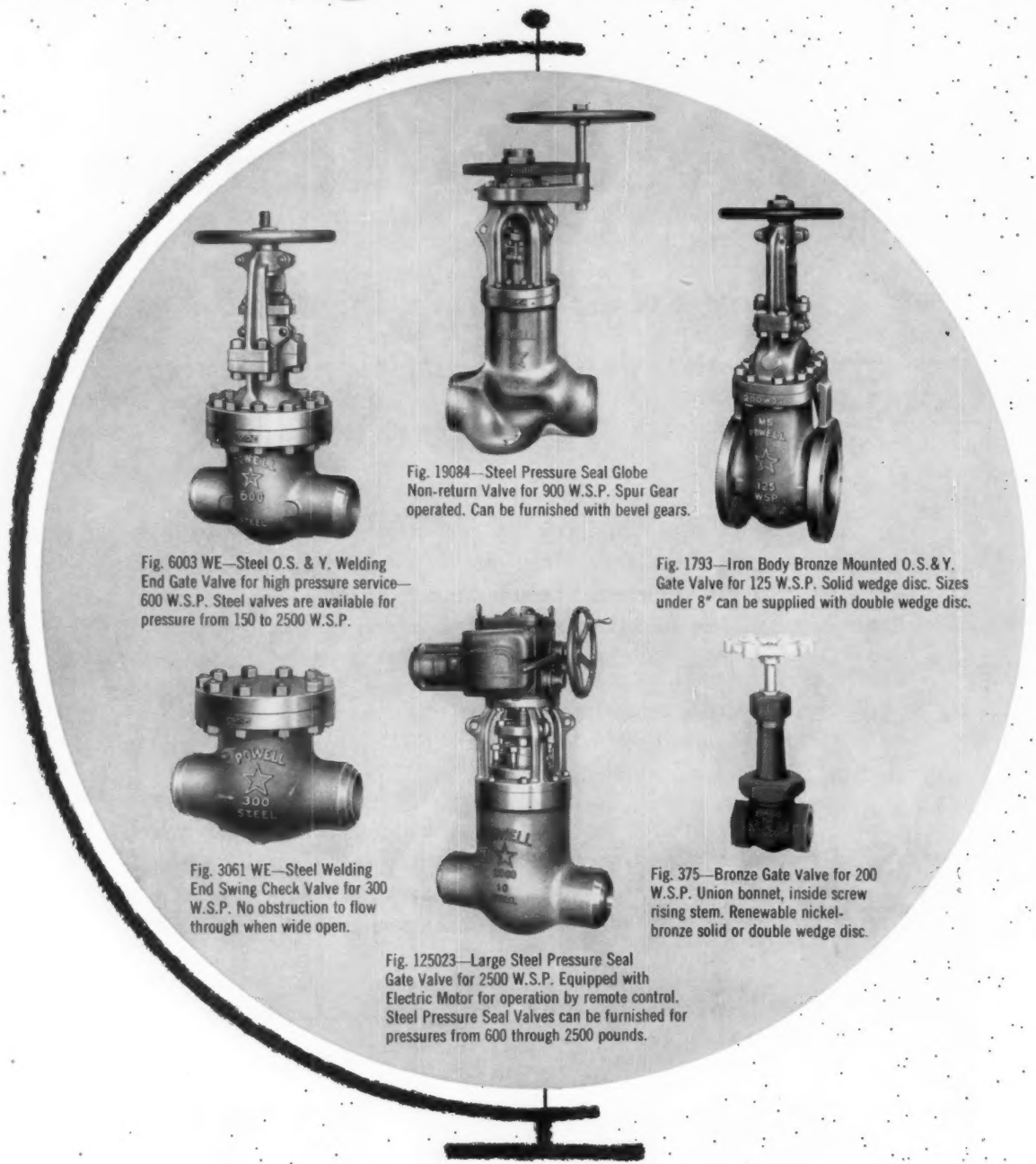

Fig. 19084—Steel Pressure Seal Globe Non-return Valve for 900 W.S.P. Spur Gear operated. Can be furnished with bevel gears.

Fig. 6003 WE—Steel O.S. & Y. Welding End Gate Valve for high pressure service—600 W.S.P. Steel valves are available for pressure from 150 to 2500 W.S.P.

Fig. 1793—Iron Body Bronze Mounted O.S.&Y. Gate Valve for 125 W.S.P. Solid wedge disc. Sizes under 8" can be supplied with double wedge disc.

Fig. 3061 WE—Steel Welding End Swing Check Valve for 300 W.S.P. No obstruction to flow through when wide open.

Fig. 375—Bronze Gate Valve for 200 W.S.P. Union bonnet, inside screw rising stem. Renewable nickel-bronze solid or double wedge disc.

Fig. 125023—Large Steel Pressure Seal Gate Valve for 2500 W.S.P. Equipped with Electric Motor for operation by remote control. Steel Pressure Seal Valves can be furnished for pressures from 600 through 2500 pounds.

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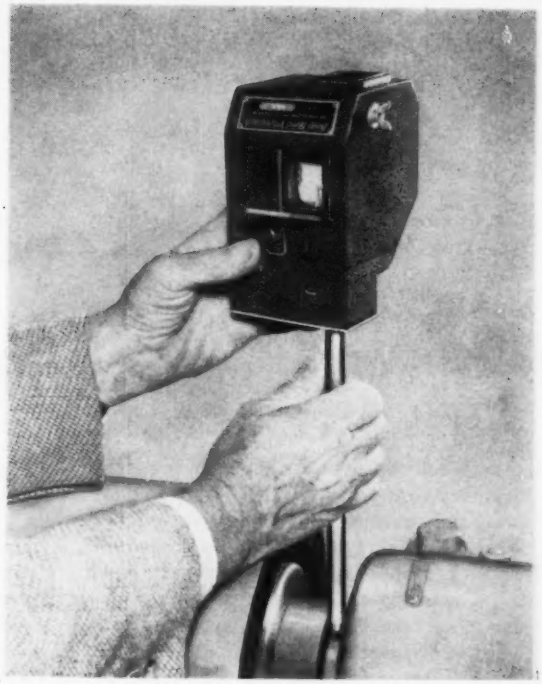
Plant maintenance and management section

STEVE ELONKA
Associate Editor in Charge



Vibrograph probe rests on shaft

To keep your equipment running . . .

You should record machine vibrations

By PETER DAVEY, The Vibroscope Co, Glenford, N.Y.

You can head off serious trouble by measuring vibration of all your rotating machinery at regular intervals. The instrument used for making a permanent record is a valuable aid, and you can file the charts for reference at any time.

Gradual increase in vibration amplitude usually spells trouble. But if you have a permanent record there's no doubt about the amount of increase. Besides, changes in the vibration wave form tell you what's going on inside the machine. This is important.

Photo shows a hand vibrograph, but you can use any instrument that makes a permanent record of vibrations.

Recording is done by a pointed sapphire stylus moving against a 1-in. wide waxed-paper chart at 1½-in. per sec. There are chart speeds of 3 in. per sec for vibrations of very high frequency.

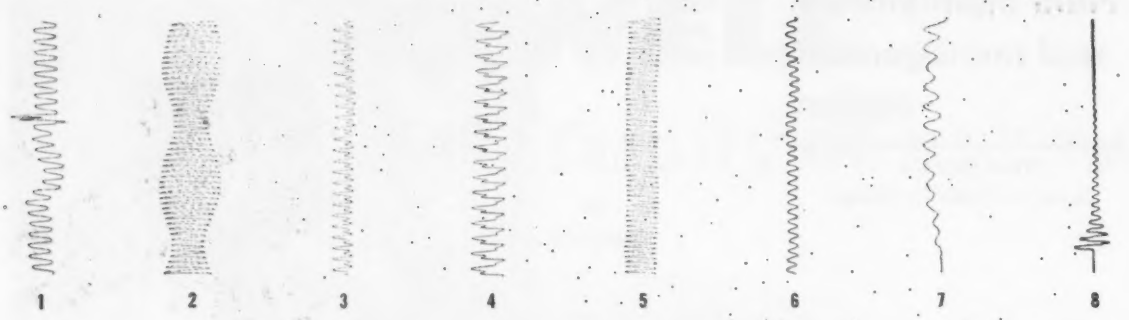
You can adjust the degree of vibration magnification to give 40: 1, 20: 1, 10: 1 or 5: 1 as desired. Since chart is run by a clockwork mechanism, no power source is needed. A probe is provided for taking readings directly on the rotating surfaces of a shaft.

Amplitude, also known as displacement, tells how much vibration exists. (See box on p 119.) Make measurement from peak to peak. We need full amplitude to evaluate the condition of the machine. The term *half amplitude* is sometimes confusing, as sketch shows. Its maximum excursion from neutral line is in one direction only. Half amplitude is used in calculations of vibration energy, because we're concerned only with amount body moves from neutral postion. Example: It takes energy to displace a pendulum from its neutral position. When released, it swings in opposite direction and continues until the same energy is used up. Amplitude is measured in thousandths of an inch (mils).

Frequency is the number of complete cycles per second or per minute and is referred to as cps or cpm.

Steady state condition exists when the same vibratory cycle is repeated continuously. Example: Unbalance in a turbine causes repetition of the same cycle once per revolution—this is steady state. But, passing traffic on a highway produces irregular patterns at irregular intervals—this isn't steady state.

Transient is an interruption of a vibration pattern over a short period. Example: If a weight is dropped on



Permanent vibration records tell you how your rotating

the floor near an unbalanced motor producing a steady vibration, shock produces a temporary peak in the curve, known as a transient, Fig. 1, above.

Sine wave is a type of vibration produced by a single frequency, such as a musical instrument playing a pure note, a swinging pendulum or a motor with simple unbalance, see box. Wave form is drawn by plotting angles from 0 to 360 deg against the sines of the angles. When another frequency is superimposed, it's not a sine wave.

Beat frequency occurs when two vibrations of nearly the same frequency are present together. Example: Two motors on the same base running at slightly different speeds produce the pattern shown in Fig. 2. Vibration amplitude pulsates rhythmically as the two frequencies come in and out of step: The closer the frequencies, the slower the "beats."

Natural frequency. Every part of a structure—and about everything in nature—has a natural frequency of vibration. This is frequency at which it vibrates if it receives a shock or other disturbance. In general, a heavier piece has lower natural frequency, while a stiffer piece has a higher natural frequency.

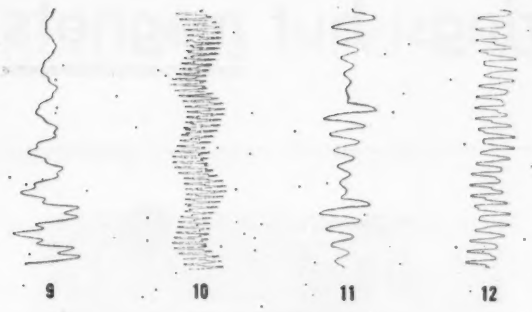
Resonance occurs when a disturbing force corresponds in frequency with the natural frequency of part of a machine. It causes an exaggerated vibration amplitude. Suppose a 1750-rpm motor with slight unbalance is mounted on a bracket with a natural frequency of 1000 cpm. On starting the motor, there would be a sudden increase of vibration amplitude just below 1000 rpm. Vibration at 1000 rpm, where resonance occurs, would be severe. But it would smooth out again after passing the natural frequency.

Critical speed occurs when a rotating shaft passes through a speed corresponding to its natural frequency as a beam, causing the shaft to bow. As critical speed is exceeded the shaft tends to straighten out again. Shaft first takes a single bow, known as first critical speed. At a much higher speed, shaft takes a double bow, called the second critical speed. Machine must be designed so shaft doesn't operate near its critical speed. In practice, value of critical speed is often below calculated value because elasticity of machine mounting adds to that of shaft and lowers the critical speed.

Harmonics. A harmonic is a frequency that combines to produce a wave form other than a sine wave. Even harmonics are the 2nd, 4th, 6th, etc; odd harmonics are the 3rd, 5th, 7th, etc. Recognizing a predominant harmonic by inspecting a vibration record often gives valuable information. Fig. 3 shows a typical wave form produced by a fundamental frequency plus a second harmonic. This could be a machine vibrating at rotational frequency with another vibration of twice the frequency superimposed. It might come from a shaft geared to run at twice motor speed or from other causes. Frequency, box, p 119, is shown graphically to illustrate how such a wave form is generated. Curve *a* is the fundamental frequency, *b* the second harmonic and *c* the curve resulting from adding them together. Here numbered ordinates are drawn every 45 deg of the 360-deg fundamental cycle. Ordinates are measured and fundamentals added to those of the second harmonic. Resulting ordinate lengths are then plotted at *c*. When they fall above the line they are plus; below the line, minus. Therefore, at No. 2 where they are both plus, resulting curve is high at that point. At No. 6 the second harmonic is plus and fundamental is somewhat more minus so resultant is slightly below neutral line. Note that curve's two halves aren't the same. This holds true where only even harmonics are present.

In contrast, Fig. 4 shows a fundamental, plus a third harmonic. Here, both sides of curve are the same, which always applies when harmonics are odd. A curve of any shape repeating its pattern, other than a sine wave, is built up of a fundamental and one or more harmonics. Given the wave form, these can be found mathematically by a method known as Fourier analysis. For field work, when record shows presence of harmonics, a Reed vibrometer is convenient for checking their frequencies. Shape of a curve varies according to relative amplitudes and phase relations of its components. But characteristics usually show principal harmonics present. It's simple to draw rough curves free-hand to study effects of varying amplitudes and phase relations.

Letter *g* refers to force of gravity pulling all bodies towards the center of the earth. If you drop a body, gravity accelerates it uniformly at about 32.2 ft per sec per sec, or one *g*. If a body is laid on a vibrating surface it accelerates up and down. As long as acceleration is less than one *g*, the body remains in contact with the surface. But if either the vibration amplitude or its frequency is increased so acceleration exceeds one *g*, the body bounces on the surface. It will be carried upward on the surface, but as motion reverses, the surface leaves it behind.



machinery is behaving

Reason: A free body cannot accelerate at more than one g. If a body is subjected to a vibration of, say, three g's the force on it will be three times its own weight.

Amplitude measurements are usually made on bearings or other external parts of machine structures. On some machines they should be taken on shaft's rotating surfaces. Although steam turbines often appear to be in good balance with bearing measurements well below 0.001 in., a reading on the shaft may show an amplitude of 0.003 in. or more. Vibrograph shown has probes for taking shaft readings. It detects vibration amplitude as low as 0.0001 in. and will measure down to 0.0002 in. Amplitudes high as ⅛ in. can be recorded. Fig. 5 shows record of 0.004 in. actual size. Fig. 6 is 0.0005 under standard magnifier, both 3600 cpm actual size. A 6.5 power magnifier gives more accurate measurement. Line the chart up with the magnifier scale which shows peak-to-peak amplitude. Frequency scale is in direction of chart travel. This represents one-half second and is graduated in 20th's of a second. To obtain frequency count the peaks in a given time interval. Records in Fig. 5 and 6 are of sine-wave form, that is, only the 3600-cpm frequency is present, which tells us that unbalance only is the cause.

Frequency measurements. Start vibration survey with measurements of frequencies present. Some cases of suspected unbalance with basic frequency of one-half rotational speed were traced to bearing oil whip. Frequency can also be twice rotational speed. One bad example was a large generator with a very light stator frame, causing 120-cycle vibration of electrical origin.

Double frequency occurs in some machines if they happen to be running close to one-half the critical speed. Here balancing isn't indicated.

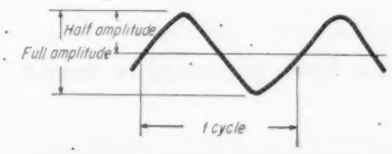
Vibration in a thread-grinding machine was causing chatter marks on the work. It looked like either the motor or grinding spindle was unbalanced. Although neither of these frequencies could be found, there was a vibration of about 0.0007 in. on the work spindle bearing at 1750 cpm. This was traced to a refrigerating unit in the machine's base. Balancing its blower eliminated the chatter marks.

How much vibration? There is no general rule for vibration tolerances because each type of machine has different characteristics. But you can have much greater amplitudes in low-speed machines. Viewed from destructive accelerating force, doubling the speed increases this force fourfold. Several published charts are useful guides to permissible vibration in power plant and like equipment. Vibration limits are generally arrived at by experience. You may find that a grinding spindle will produce chatter marks in the work if vibration amplitude exceeds 0.0002 in. So make regular checks and correct any increase. A tubular-wire strander may be trouble-free while tube vibration doesn't exceed 0.008 in. Beyond that figure there may be bearing failure. Regular vibration checks will prevent this from happening.

When a machine is running OK, with a certain vibration amplitude, the thing to look for in preventive maintenance is any sudden increase of that amplitude, or any change of wave form.

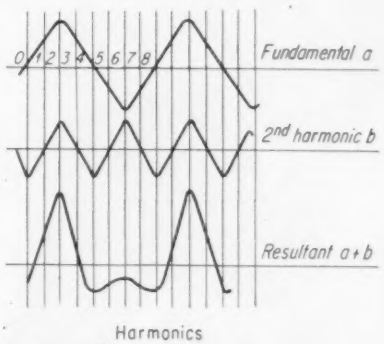
Resonance. Cause of excessive vibration may often be a machine mounted on a structure with a natural frequency close to its rotational speed. Most usual indication

(*Continued on page* 173)



AMPLITUDE . . .

shows amount of vibration, and is measured from peak to peak. Half amplitude is maximum excursion from neutral line in one direction. It is used to calculate vibration energy, because we must only know distance body moves from neutral position



FREQUENCY WAVE FORM . . .

shows how such a wave form is generated. Curve *a* is fundamental frequency; *b* is the second harmonic; *c* the curve resulting from adding *a* and *b* together. The numbered ordinates here are drawn every 45 deg of the 360-deg fundamental cycle

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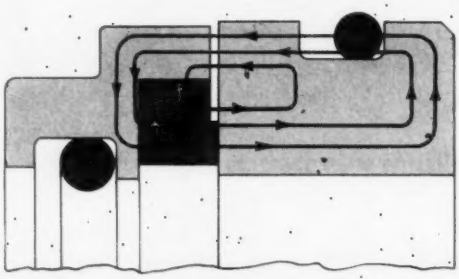
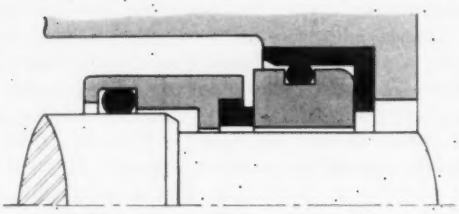
Not springs, but magnets

Let's see how the seal is made



FLUX PATH, shown by solid lines, goes through the two seal rings, holds them together; no spring needed



FEW PARTS are needed in this seal as magnetic force, O-rings and sealing rings complete the seal package

Here's how the seal works

Newest addition to the rapidly growing mechanical-seal family is this magnetic unit. (See POWER's special report on *Mechanical Seals,* March 1956, pp 109-132). Here, magnetic force keeps the seal faces together when the unit is shut down, instead of a spring or bellows used in other types.

Magnetic force allows a more even seal face pressure, so wear on faces is more accurately controlled. This feature allows seal to be run with dry faces at fairly high surface speeds. Contact point between faces can be narrow because of the controlled force, helping to dissipate heat rapidly.

Seal has been used to 5000 psi at 550 F and at shaft speeds to 20,000 fpm. Claim is that it can be used on any job suitable for a conventional mechanical seal, and on several where other seals aren't practical.

An important feature is that this seal doesn't have to be positioned. No set screws are needed because of the low mass and starting inertia of the seal ring, and an O-ring with a normal amount of compression gives enough force to drive the seal ring. Since seal ring is driven by a resilient O-ring, it has a tendency to align itself and run concentrically with the shaft.

Advantages claimed include: (1) ease of assembly (2) self positioning (3) self-aligning (4) compactness (5) fewer parts (6) constant load (7) easier interchangeability of parts and (8) much less possibility of distortion.

One disadvantage is that an insulator may be needed if the gland is a magnetic material. To combat this, the seal manufacturer supplies a nonmagnetic gland.

Permanent magnet loses about 25% of its charge in two to three days after manufacture. Then there is little loss for several years. As for heat, the Alnico-5 used retains 80% of its magnetism at 1184 F, 60% at 1400 F; at 1652 F the magnetism is lost completely.

Question often asked is if the pump casing material affects the magnetic force in the seal. The answer is "No," because only place magnetic force must be shielded is in the gland. And gland supplied with the seal is shielded by 300-series stainless steel, or some other nonmagnetic material. If user supplies gland, seal maker furnishes a thin insulator for press fitting into gland. Sketch, above, shows the flux path through the two seal rings.

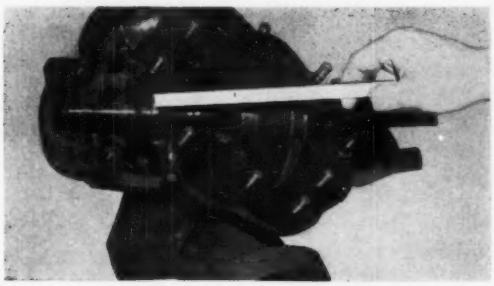
Shaft material does not affect the magnetic force of the mating ring because the flux path is such that the shaft won't disturb it.

Another question that often crops up: Does this seal pick up magnetic particles from fluid being sealed? Experience is that a small amount does stick to the outside diameter of the magnet but centrifugal force keeps the critical sealing faces clear. To date, the seal has been

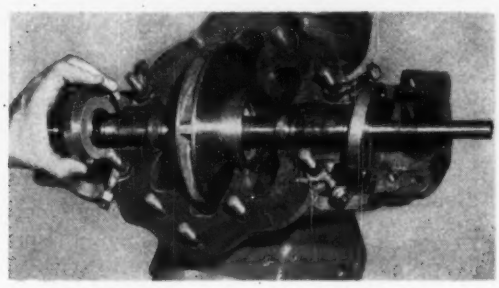
hold this mechanical seal together

By STEVE ELONKA, Associate Editor

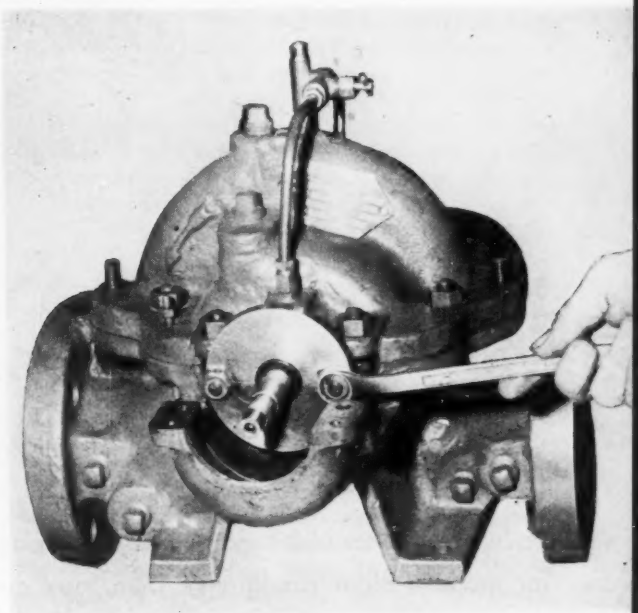
Installing the seal is simple



1 First step after cleaning and lubricating the shaft is to slip the seal ring into the position shown by the rule



2 Slip the gland assembly over the shaft. Let the assembly click together very gently to align with the seal ring



3 Close up the pump, then tighten the gland bolts evenly. Gland is automatically centered in the box by the pilot.

made for some very large shafts, up to 14-in. diameter.

Sealing ring is usually of 400-series stainless steel or some other suitable magnetic material. Mating ring is of Alnico-5 (20% nickel, 8% cobalt, 12% aluminum, 60% iron). Since Rockwell-C hardness of Alnico mating ring is No. 52, it compares with the hardest metals.

Carbon rings are either pure or synthetic. They can be impregnated with materials like silver, copper, moly-disulfide—depending on the particular application.

Surface speed. Remember, rpm doesn't indicate a limiting factor. Since surface speed is important, these seals can be operated at 20,000 fpm. This is equivalent to a 1½-in. shaft running at 40,000 rpm.

The seal is precision made and usually custom built, so handle it as you would your watch. Keep contaminants such as dirt, grit or abrasives from the seal faces. The faces are finished to within a few microinches, and must be flat to within a few light bands. WARNING: Don't scratch the O-rings during assembly. Any sharp edges or keyways over which O-rings must slide should be chamferred and blended with shaft to prevent scratching. A little oil on the shaft will help protect the O-ring during installation.

Follow manufacturer's recommendations for installing. Mishandling can ruin this or any other seal. Never slide the seal faces across each other; always pull the ring directly apart.

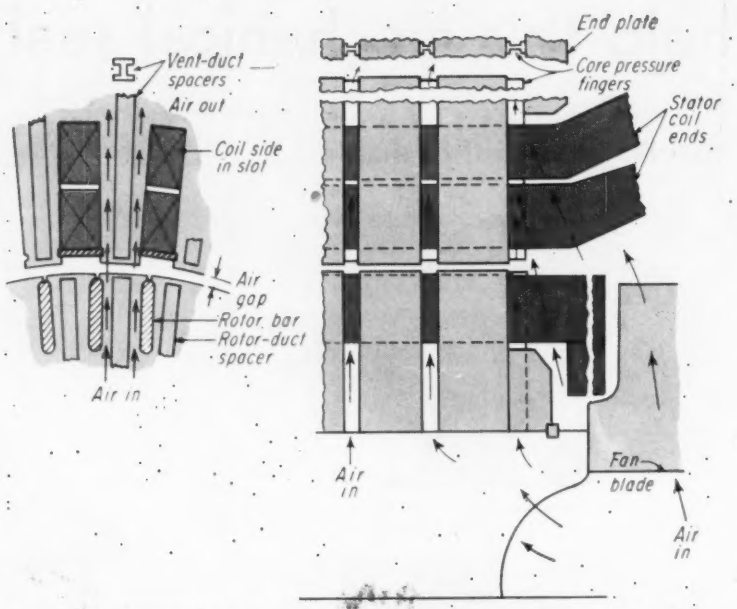
Axial length of magnetic seal is so short, that a complete double-seal unit mounted in its own small stuffing box can be attached to a pump housing. Projection of this seal beyond the stuffing-box face is less than 2 in.; the actual amount depends on the application.

Abrasive, corrosive or high-temperature fluids are hard on seals. But they can be tamed by circulating a clean fluid between the seal and sealant fluid. In temperature problems, circulate the same fluid at a lower temperature to keep the seal in safe range.

End play. All revolving shafts have some end play. If end-play movement is slow, such as shaft expansion caused by temperature rise, there's no problem. Besides, a shaft usually rides in one position. This seal handles end play of up to 1/32 inch.

You can convert from a jam type packing to a mechanical seal even if your shafts aren't standard. But difference in shaft diameter does affect compression of the O-ring on these seals. If your shaft is slightly large, O-ring is overcompressed; if undersized, O-ring is undercompressed. Latter is a less desirable condition. Maker's brochure indicates diameter best suited to seal's O-ring.

—Courtesy, A W Chesterton Co, Everett, Mass.



1 Typical arrangement of central vents, end-pressure fingers and fans at end of the rotor has air paths which will produce noise. Magnitude of noise depends on arrangement

By R C MOORE
Allis-Chalmers Manufacturing Co

Do you have an older motor that is making too much noise for modern plant conditions? Then look over these suggestions on how . . .

Motor noise can be reduced

Noise consciousness in recent years has brought about a noise reappraisal of older electric motors since these are likely to operate at a louder pitch than modern machines. Concern about noise arises most frequently from a desire for more pleasant working conditions. Irritating sounds can adversely affect efficiency and health. Sometimes a neighborhood changes and homes are built close to a building housing an offending motor. Here, too, the noise problem will probably require attention.

There are four parts to the problem of quieting older machines: (1) What is the origin of noise within the motor? (2) How can you reduce noise generation? (3) If reduction of noise at the source is impractical, what can you do to reduce the noise energy in transmission to the persons affected? (4) What are the comparative costs of the various solutions?

Two major causes of noise in induction motors are air flow and magnetic forces. Resulting noises are usually called *ventilation noise* and *magnetic noise.* Ventilation noise arises from fan air turbulence, siren effect of ventilating passages, etc. Cause of magnetic noise is the vibration of mechanical parts produced by magnetic forces.

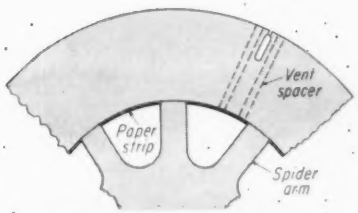
Since both types of noise may exist simultaneously, you'll have to make tests to detect these distinctions. After determining the type of noise source, you'll have to find out whether single or multiple sources exist and where they are located.

Types of noise can be determined from simple tests, one type of noise being independent of the other:

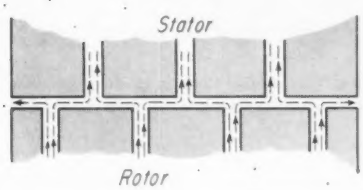
Test A—Ventilation noise. Run the motor idle, then suddenly disconnect it from its power source. Any noise observed after de-energizing must be ventilation noise since magnetic forces are no longer present after removal of voltage from the motor.

Test B—Idle magnetic noise. Run the motor idle at full voltage, then disconnect the voltage. If the noise intensity drops after de-energizing, the noise reduction is caused by the disappearance of magnetic forces which produced the vibration. You can conclude that magnetic noise existed when the motor was energized; any noise remaining after de-energizing is ventilation noise.

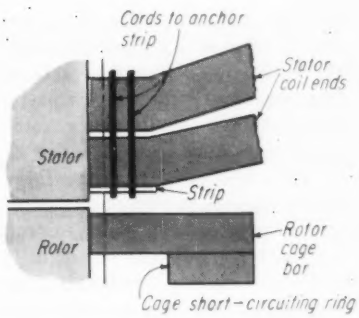
Test C—Variable voltage. If a source of variable voltage is available you can utilize it to determine the presence of either ventilation or



2 Blocking ducts, with paper strips at back of the core, tests for duct noise



3 Staggered vents in some motors reduce the siren type of ventilation noise



4 Insulation strip placed around circumference of stator coils blocks air

magnetic noise. Increasing or decreasing the voltage relative to rated value will cause the forces producing magnetic noise to vary. At low voltage the magnetic noise may practically disappear in many cases; only ventilation noise remains.

Test D—Loaded magnetic noise. There are two kinds of magnetic noise. One kind, discussed in tests *B* and *C*, remains steady in magnitude whether the motor is loaded or unloaded. Another kind appears only when the motor is loaded and will decrease with decreasing load. In fact, the motor may run quietly at no load.

Ventilation noise is generated by the rotor in induction motors. Principal sources are central ventilating ducts, core-end pressure fingers and rotor-mounted fans. Typical arrangement of these parts is shown in Fig. 1, page 122. Arrows indicate air flow. The same general noise analysis applies to other types of fans.

When running at full speed the central-ventilating ducts may be the most important source of ventilation noise. Rotor ducts in cooperation with stator ducts across the air gap can produce a siren effect. If you measure it with sound-frequency testing instruments the noise frequency in cycles per second corresponds to the number of rotor ventilating ducts times the rotor rpm. If possible, make the test at reduced voltage to minimize the contribution of magnetic noise when its presence has been previously determined.

A practical method to evaluate noise intensity from the combined system of central-ventilating ducts and core-end pressure fingers is to temporarily block off the back of the rotor core by placing heavy paper strips between spider arms, Fig. 2. Strips should cover the entire core length including core-end pressure fingers. If necessary use masking tape to cover ventilating ducts instead of paper strips. Thus blocked, noise from ventilating-duct sources will be noticeably reduced.

Some motors have a staggered arrangement of ventilating ducts, as in Fig. 3. Air flow from rotor to stator is through the narrow air gap, resulting in noise suppression. (There's also a reduction of air flow through the duct system. Allowance has been made in the original design, of course.) When these motors are repaired the new stator-slot wedges must be of the same shape and dimensions as the original, otherwise noise can result from effect of slot wedges.

Band wire may be found over the rotor-bar end extensions in some older motors, with insulating material under the wire to prevent short-circuiting the bar ends through the wire. If insulation over the bar-end extension and pressure-finger regions is placed properly, air movement is prevented and noise generation reduced. After repairing or replacing rotor bars in such machines, carefully restore the original band-wire arrangement to get minimum noise with adequate air cooling.

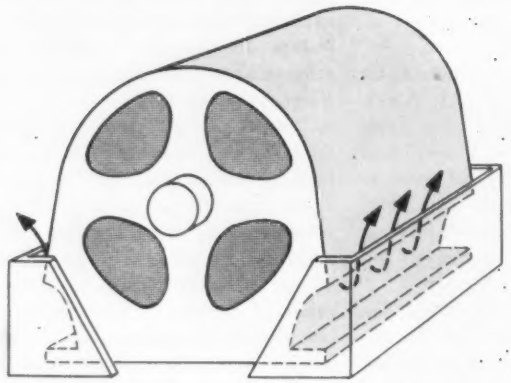
Fan-noise analyses sometimes disclose no particularly outstanding loud component of a single frequency. There may be a "rushing" sound, referred to by some engineers as a *white-* or *broad-band* noise because of its characteristic of including a range of frequency components, no one of which is outstanding. In other cases of fan noise a single frequency component may be outstanding in a broad-band background of noise. Its frequency in cycles per second is number of fan blades times fan's rpm.

Reduction of ventilation noise at the origin can be accomplished by reducing air through the ducts. This method is seldom resorted to because it's likely to result in increased motor heating. Rarely will it be economical to reduce horsepower capability to lessen noise while staying within proper temperature limits. In general it's more practical to absorb noise energy from this source along the transmission path without appreciably reducing volume of air flow.

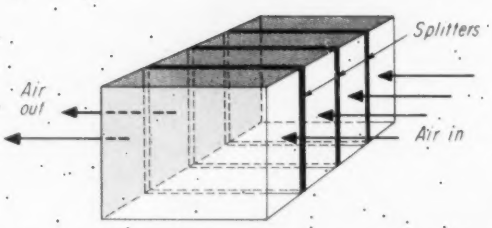
Noise generated by the rotor-core pressure fingers can be reduced considerably by preventing air movement through them. This can be done without perceptible increase in motor heating because there is usually sufficient cooling air in the vicinity of the coil ends. A method sometimes used is to block the inner-diameter openings of the fingers. You can accomplish this in some older motors by lacing narrow strips of insulation on the inner diameter of the stator coils opposite the fan, as in Fig. 4.

Fan noise can be caused by poor aerodynamic design or by the turbulence effects in the fan or in the air stream blowing against the stator-coil ends or projections opposite the fan. Installing fans of better aerodynamic design and experimenting with diffusers and baffling arrangements is one approach, but it may be costly. Furthermore, the inherent noise level of even well-designed high-speed fans may be too high to obtain an acceptable fan sound level. You would also have to test motor-cooling effectiveness of replaced fans or baffling.

A practical solution in the above instances is to reduce noise in the



5 Muffler or sound-absorbing structure can be installed at the exhaust openings of the motor frame without blocking air flow



6 Sound-absorbing structure has splitters in path of air flow. Splitters are "sandwiches" with perforated metal on the air sides

When it's not practical to reduce cause of noise generation,

transmission paths. Here, noise can be reduced by a number of methods and devices which absorb sound energy from the motor ventilating air so a minimum of noise will be detected outside the motor. In new motors noise suppression measures are an integral part of the frame construction. Older motors often have insufficient space in the frame to install sound-absorbing devices.

Prominent single-frequency components are sometimes more noticeable at the air-exhaust openings than at the intake openings. You can easily test this by momentarily blocking one of the motor exhaust openings and noticing whether there is a reduction of noise at the blocked side. If the test indicates a noise reduction, then sound-absorbing structures or mufflers are likely to be effective at the exhaust openings. A muffler should both reflect and absorb sound. Reflection is more effective for low frequencies and absorption for higher frequencies (above about 1000 cps). One type of sound-absorbing structure, Fig. 5, is built of metal panels of special construction. Typical panel has two sheet-metal plates between which are sandwiched sound-absorbing material such as glass fibers. The metal plate facing the air stream is perforated with small holes. The other plate needn't be perforated.

A more elaborate and more expensive muffler using splitters, see Fig. 6, may reduce the sound level below that obtained from construction of Fig. 5. This type can be particularly effective to reduce a single-frequency component by proper proportioning of the splitter spacing length, etc. Splitters are similar to muffler panels.

Mufflers can also be adapted to intake openings, Fig. 7.

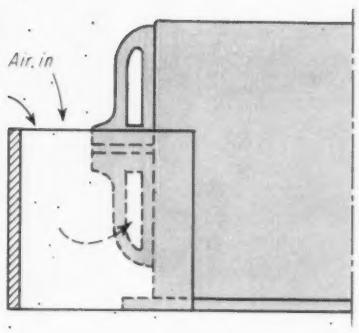
Enclosures around motors may warrant consideration in some locations. A partial enclosure formed by judiciously placed large acoustical panels serves to interfere with noise transmission, Fig. 8. An enclosure that completely isolates a motor must be designed to provide adequate ventilation and may require a special blower to handle air-pressure drops in intake and exhaust ducts.

Spraying or otherwise depositing sound-absorbing material on accessible portions of motor covers and bottom plates is sometimes effective. In other cases frame air openings are so large that little noise energy contacts the treated surfaces.

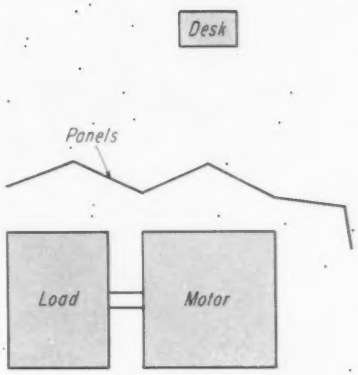
Magnetic noise in induction motors is mainly caused by harmonic magnetic fields superimposed on the fundamental field of the air gap. Harmonic fields may arise from permeance variation of the slotted stator and rotor, or to phase-belt and slot-harmonic mmf's. These fields excite motor parts into vibration. The noise frequency may be fairly high—above 1000 cps. Vibration of a particular part will be amplified when resonance with driving-force frequency occurs.

An important source of magnetic noise in 2-pole motors is the force wave that produces radial forces of twice line frequency (120 cps for a 60-cycle supply), acting on the stator frame structure. At a given instant, when the centers of the two magnetic poles are lined up vertically, the maximum forces they develop also occur in a vertical axis. The frame wrapper, for example, is pulled inwardly at the top and bottom, Fig. 9. One-half revolution later the two poles and the pole forces are lined up vertically again, and again deflect the wrapper inwardly. On one revolution the wrapper is subjected to two cycles of deflection in the vertical axis, and in 60 revolutions per second (3600 rpm) to 120 cycles deflected frequency. This force frequency also occurs at any other axis from the vertical. Analysis of successive axes demonstrates rotation of the 120-cycle force wave. Actual deflection of parts caused by the moving force wave may differ because of differences of frame-structure rigidity in different axes.

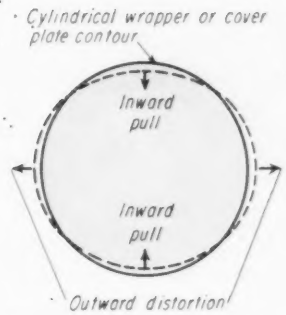
Long-period modulated magnetic noise in some high-speed motors under load often is referred to as "slip-beat" noise. Its period in cycles per minute is equal to the number of poles times the slip rpm. If, for ex-



7 Air-intake openings can be fitted with a sound-absorbing structure if necessary



8 Panels absorb sound in path of desk, are as close to the motor as practical



9 Distortion of the wrapper plate occurs when the two poles are aligned vertically

try absorbing noise energy in the transmission path

ample, the slip of a 2-pole 3600-rpm motor is 0.7%, the slip rpm is about 25. The noise period is 50 cycles per minute. As the load and resulting revolutions of slip decrease, the period decreases. Because the modulated noise slowly builds up to a peak and then practically disappears between peaks, it may be annoying. Its presence may produce severe vibration in structural parts.

Another source of magnetic noise, caused by core-teeth vibration, may develop during the lifetime of a motor. It often has a buzzing sound. It's caused by loosening of the core and clamping parts, or because of relaxation of the core due to "seasoning" of the core iron, or both. The core punchings act like a large number of stacked Belleville springs. Remedy for tooth vibration is, of course, to restore the original core clamping pressure.

Appreciable reduction of magnetic noise at its source may be possible by changing the machine design. However, rebuilding the stator or rotor for a different number of slots or skewing the slots is costly—a cost that may not be justified in view of age or condition of motor, its insulation, etc.

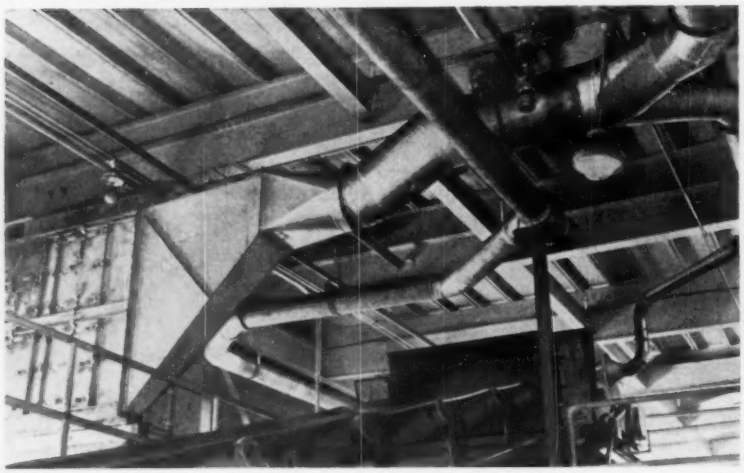
First investigate less costly methods which don't go to the magnetic source, but instead reduce the amplitude of vibration of the noise-generating parts. Motor teeth, for example, transmit magnetic force variations to which they are subjected at the air gap directly to the core, and thence to all parts to which the core is attached. Because all parts, including supporting members, wrapper plates, etc, normally are rigidly interconnected, the possible sources of noise-radiating surfaces then become large. (For this reason methods used successfully to reduce ventilation noise are often ineffective when applied to magnetic-noise problems.)

Motor parts vibrate to a greater or lesser degree depending on (1) their resistance to the exciting forces or (2) whether the part is in resonance with the exciting frequency. In case (1) increasing the resistance of the part that is forced to vibrate will reduce the amplitude of the vibration and therefore noise generation. Mastic compounds applied to vibrating surfaces often don't increase resistance of the vibrating part sufficiently; making the part heavier or using stiffening members is more effective. In case (2) it may be possible to weld on stiffening ribs or pipes to alter the natural frequency and remove it from the exciting frequency, thus reducing noise generation.

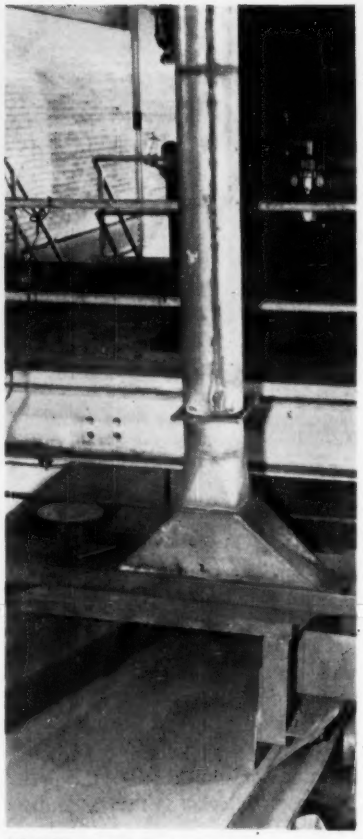
Before locating stiffening members permanently, preliminary tests may be made to determine their most effective location. Make explorations using vibration pickups or deflection gages where accessibility permits. Experimentation may be done in difficult or relatively inaccessible locations using temporary wooden wedges, blocks or jacks at the suspected places. Such procedures may appear hit-or-miss, but they may be the most direct approach if used with good judgment.

Other sources of noise than ventilation or magnetic types can occur in a motor. They may be caused by loose bearing shells in the bearing holders, bent or warped shaft, misalignment with the driven machine, mechanical unbalance, etc. The noise developed by these sources is often of impact type and not associated with any particular frequency of recurrence. Detection and corrective measures involve putting the motor in tip-top mechanical condition. These are not inherent motor noises.

Expert service may be called for if you've got a tough problem. The nature of noise and the problems associated with reducing it may be analyzed more quickly and solved by employing the services of a qualified acoustic engineer (in tough cases this will probably be less costly). His experience with sound-level problems and materials, modern sound-measuring instruments and techniques is desirable. In cases of magnetic noise especially, the services of a motor-design engineer may also be advantageous. Fundamental design changes are indicated in some noise problems.



DUST COLLECTOR, suction duct are connected to upper part of conveyor transfer chute



LOWER part of chute, dust curtain removed

Huntley Station's miniature cyclone units . . .

Stop explosive-gas and coal-dust hazards

By J M CHAMBLISS, Mechanical Engineer
Niagara Mohawk Power Corporation

Controlling coal dust and preventing accumulation of explosive gas released by stored coal were two problems given careful consideration during the design phase of Niagara Mohawk Power Corp's new 200-mw steam-generating unit at Huntley Station. As a result, these problems don't exist today.

Controlling coal dust. A 1200-ton-per-hr conveyor system delivers coal for the new unit to an enclosed 2000-ton capacity bunker in the powerhouse. System has three transfer points in the new section, arranged to feed coal into the bunker at two points. At these dusting sources, problem was solved by installing a Dustex exhauster-collector unit which, in effect pulls air into the transfer chutes. By drawing a sufficient volume of air from each chute, velocity of the replacing air entering the chute through various openings effectively prevents dust from escaping into the room. Chutes have dust curtains at the conveyor inlets and outlets, and are otherwise enclosed so far as practicable to minimize the quantity of air to be handled by the exhauster-collector.

Standard exhaust fan and a miniature cyclone type dust collector, containing 70 abrasive-resistant cast-white-iron tubes, comprise the unit which is rated 5950 cfm at 70 F, 6-in. wg. Coal-dust-laden air from the transfer chutes is drawn through the collector. Relatively dust-free air is discharged outside the building and collected dust is discharged into the bunker.

Since the collector operates under negative pressure, a special vacuum valve housed in a metal tube with flanged end connections is used on the dust-hopper outlet. Nothing complex, it's simply a neoprene-rubber sleeve specially formed to collapse under vacuum and maintain a seal. As the dust collects above, its own weight forces it through the sleeve.

Trapping explosive gas. Another exhauster-collector (48 tube, rated 4300 cfm, 7-in. wg) solved problem No. 2—that of preventing explosive-gas accumulation in conveyor room and bunker below. Air and gas are drawn from top of bunker through a large connection in the bunker roof, pass through collector and discharge outside the building. Replacement air enters the bunker through clearances in the feed chutes. This ventilates upper unfilled portion of the bunker and prevents gas concentration. It's necessary to use collector rather than to discharge directly to outside because considerable dust forms in bunker when unloading coal. Collected dust goes back into bunker at same distance from air-suction connection to minimize the amount of dust recirculation.

In operation for several months, system does an effective job. Collector tubes haven't plugged and need for overall maintenance has been slight.

ALUMINUM AND ASBESTOS team up to form new flexible duct installed in Chicago Federal Reserve Bank building. Special fire resistant duct handles installation of high- or low-velocity air distribution in cramped quarters or around other ducts, as above

Flexible air duct trims installation costs

Chicago builders tried out a new wrinkle in air-duct construction in the Federal Reserve Bank of Chicago. They took a close look at high costs in air-duct construction, came up with a system that saves money in new construction and pays off in modernization or rearranging of air-conditioning ducts.

New system incorporates flexible ducts in areas where multiple bends and tight quarters usually boost installed costs of standard duct. Flexible ducts easily handle several types of air conditioning installation problems: connections from branch ducts to high-pressure side of attenuation boxes and from branch ducts to ceiling outlets, connections from vertical risers to under-window units, runouts from attenuation boxes to ceiling outlet octopus system and vertical takeoffs from branch ducts to ceiling outlets on low-pressure systems.

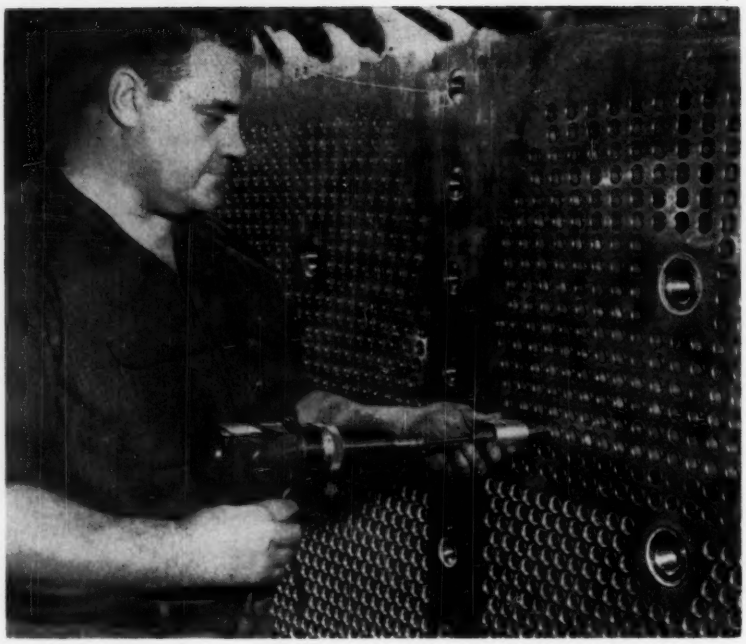
Flexible duct has been available for some time, but Chicago's strict building codes prevented use of any duct which did not qualify as fireproof. After eight years of work, a new fabric produced by U.S. Rubber Co filled the bill. It set the stage for manufacture of an asbestos-lined duct that under test successfully contained 2000-F flame for more than four hours. New duct consists of flame-resistant, UL grade asbestos cloth protected by laminated, polyester-reinforced aluminum foil, galvanized steel spiral. Fabric and metal are locked together mechanically for the life of duct. It's manufactured by Wiremold Co, comes in 3 to 12 in. ID, up to 20 ft long.

Relative costs for standard vs flexible duct are hard to generalize since cost of standard duct varies considerably across the country. You will usually find flexible duct is more expensive than straight run standard, but as soon as you start adding bends the price picture begins to favor flexible duct. When you evaluate installed labor costs, flexible duct usually rings up a clear-cut saving in total price. The new ducts contribute even greater savings in high-velocity systems because of higher costs of standard ducts for this use.

In old buildings flexible duct is a real cost saver since it bends without kinking, making it easy to install around structural members and in cramped quarters with little or no cutting of walls and floors.

Other advantages are low friction and no odor under operating temperatures—important in food-processing plants. Ducts are oil and acid resistant as well; never need painting. This quality of the fabric cuts maintenance costs and has led to its use as a covering material for piping insulation in heating and refrigeration systems.

NEW EXPANDER handles thickest tube sheets in a continuous-rolling operation



TUBE ROLLING in heavy tube sheets speeds up when using new expander and continuous-rolling technique. Expander can be used for either protractive or retractive rolling

Higher-pressure heaters

Today's heat exchangers require much heavier tube sheets to withstand operating conditions. Here are some tips on tube rolling to help you service these high-pressure units

By HOWARD A BACH, Elliott Company

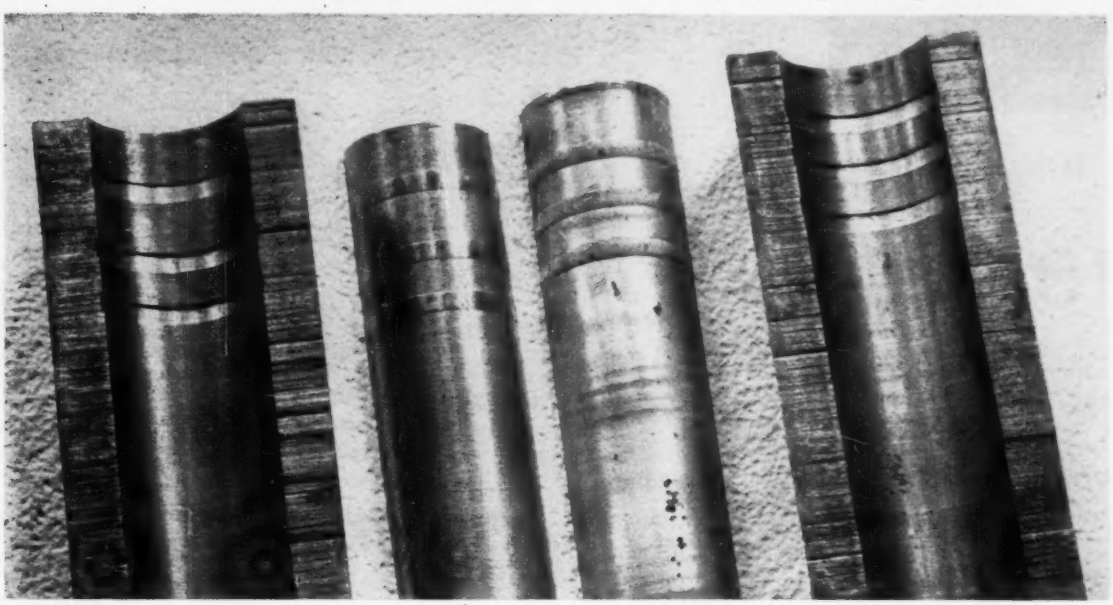
Rolling tubes into tube sheets of heat-transfer apparatus was more of an art than a science until skyrocketing operating pressures required thicker tube sheets. Now old methods are inadequate and rolling tubes in high-pressure heat exchangers must be approached scientifically.

Thin tube sheets used in standard heat exchangers permitted adequate tube rolling in a single operation. As pressures increased, thicker tube sheets were required. Standard one-pass rolling could not penetrate these thicknesses, pointing up need for a new tube rolling method. At that time, only two rolling methods were available, the standard single-pass type and step rolling.

Tube rolling is basically a cold working operation; it toughens metal by deforming it. Tube metal is forced to flow longitudinally and radially by the expander rolls. The final outside diameter can't be larger than the tube-sheet hole, assuming no deformation. Rolling force must exceed yield strength of tube metal. This force dissipates radially, giving adherence between tube and tube sheet, and longitudinally causing tube extension. The adherence is a result of metal flow into tube-sheet hole surface.

There is an optimum amount of tube rolling required by any given tube. Under-rolling and over-rolling prevent a tight seal, but for different reasons. Under-rolling is self explana-

Continuous-rolling technique gives better seal than older step-rolling method



TUBE SAMPLES rolled by continuous method, *above left*, show uniform, mirror image surface of tube OD with no signs of shear. Step-rolled sample, *at right*, typifies the nonuniform surface and shear rings produced where incremental rolling reworks metal

turn tube rolling from art to science

tory, but over-rolling is caused by severe deformation beyond the optimum point. Since tube can't expand beyond tube-sheet hole diameter, it must extend. As the conventional expander over-rolls the tube, metal flows approximately 60% forward, 40% to rear. This flowing action shears small keys that give adherence between tube and tube sheet.

In step rolling, tube is rolled by increments along its length within the tube sheet. Result is overlapping rings of over-rolling. The roll nose of each succeeding pass re-rolls tube portion previously worked by roll heel. Shearing mechanism, caused by flowing metal, leaves smooth microscopic corrosion sites on the tube OD; erratic nonuniform over-rolling leaves an uneven tube ID in its wake.

The alternate single-pass method rolls for a portion of tube-sheet thickness. Method is limited by the length of the rolls in expander which, in turn, is limited by roller-cage feed angle. Rolling process seals the open end of the tube, but about 0.010 in. annular space surrounds the remaining length of unrolled tube inside the tube sheet. This void space presents an excellent source of crevice corrosion, so should be avoided.

Improved expander, developed by Elliott Company, solved many problems common to step rolling. New method allows continuous rolling, which eliminates annular voids, shear rings and erratic tube ID.

When both ends of a tube are retractively rolled, extruded tube ends must be trimmed. But protractive rolling of both ends causes compressive stresses. When heat-transfer equipment goes into operation, tubes under compression tend to bow; those under tension tend to pull inwardly from tube sheets. In both cases, the rolled portion can be unseated. A single combination of protractive rolling for one end and retractive rolling for the other eliminates the stresses that cause unseating. The improved expander can be used for both operations. When rolling protractively, rolls disengage and expander can be removed from tube without reversing driving motor. New expander incorporates individual travel of cage, rolls and mandrel. There is no skidding, slipping or unnecessary mandrel breakage; wear to rolls and mandrel is reduced to a minimum and rolling speed increases tremendously. Samples of continuous rolling, photo above, were rolled at 1000 rpm, but higher speeds can be used. New method requires less torque than with step-rolling.

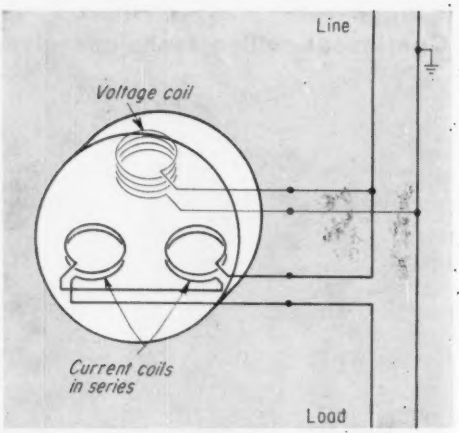
Expander rolls at about one inch in 2.5 sec. Rolling time for the 3⅝-in. tube sheets in the photo was 9 sec. Time required for step rolling would be 27 sec because of need to extract and re-enter tube for each step. In effect, thicker the tube sheet, greater the savings. The new equipment has already been applied to various gages of brass, cupro-nickel, stainless steel, monel metal and aluminum—all with successful results. Expander can be manufactured for any sheet thickness. Specifications must state tube-sheet hole ID, tube material, OD and ID.

NO. 31: WATTHOUR HOOKUPS

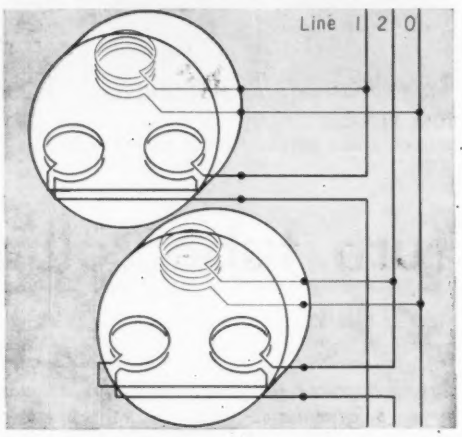
10 hookups for watthour meters

By NORMAN PEACH, Assistant Editor

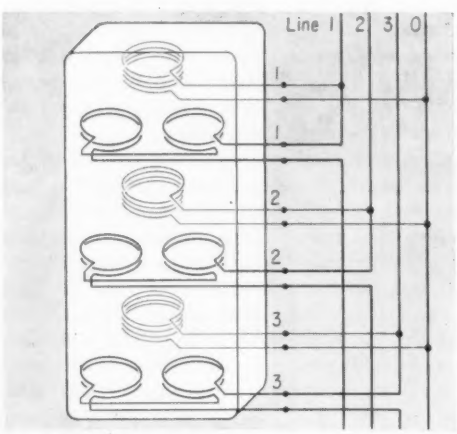
How the basic types of polyphase watthour meters work was discussed in last month's *Fact File*. Polyphase meters are made up of elements that amount to single-phase meters. Ten meter hookups in common use for single-, 2- and 3-phase circuits are illustrated on these pages. Some of the meter elements shown have two separate current coils with all lead brought out; others have the current coils in series, making a "single-coil" element. Actual turns, wire sizes, etc depend on type of circuit being metered. Current and potential transformers can be used with any of the circuits shown when amperes and volts are too high for the meter elements. Transformer polarity must be checked carefully.



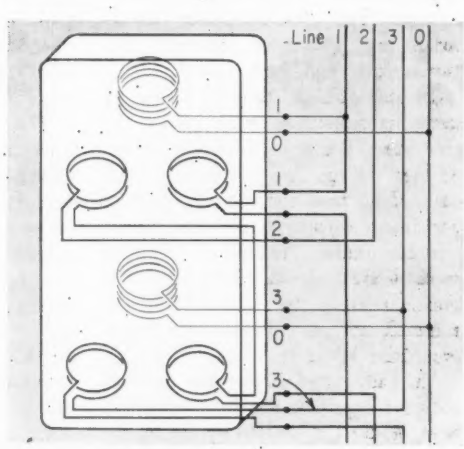
1 **GROUNDED 2-WIRE SINGLE-PHASE** circuit with 2-wire single-phase meter. Where loads are small, voltage coil may be put on load side



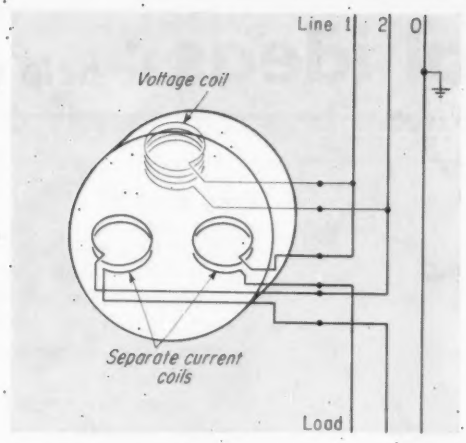
4 **3-WIRE SINGLE-PHASE CIRCUIT** with two 2-wire meters or a 2-element meter. Accurate even when line-to-neutral voltages are unequal



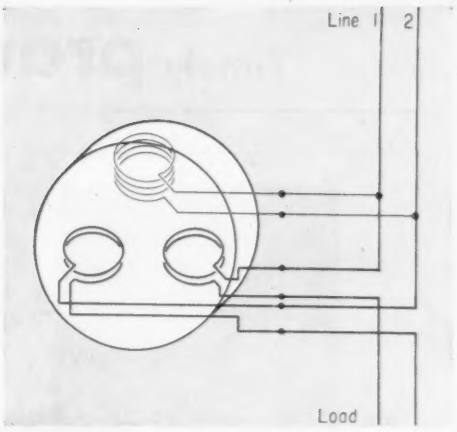
7 **4-WIRE 3-PHASE WYE** circuit with a 3-element meter. On a delta system one element has twice voltage, half current rating of the other two



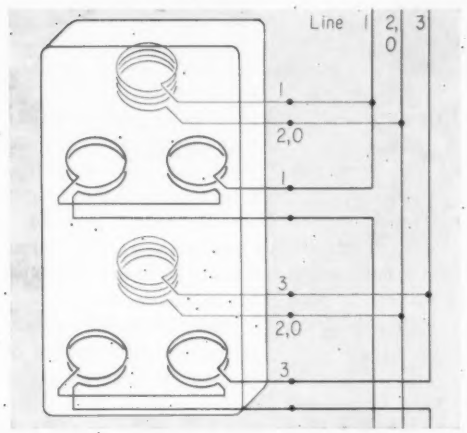
8 **4-WIRE 3-PHASE WYE** circuit using a 4-wire 2-element split-coil meter. This method assumes that the line-to-neutral voltages are equal



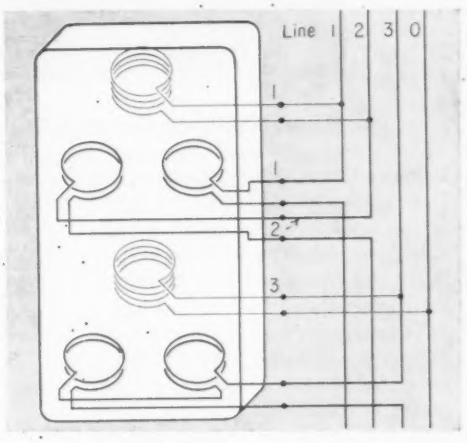
2 **GROUNDED 3-WIRE SINGLE-PHASE** circuit with 3-wire single-phase meter. This method assumes both line-to-neutral voltages are equal



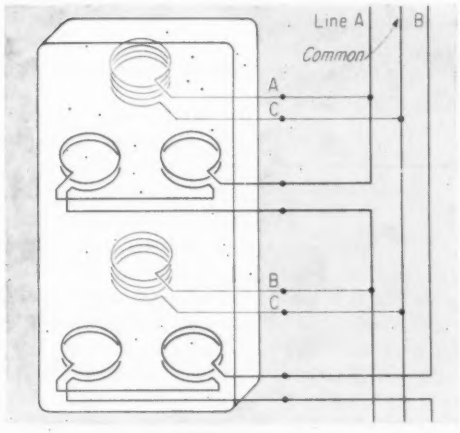
3 **UNGROUNDED 2-WIRE SINGLE-PHASE** circuit with a 2-current-coil, 3-wire meter. Used to meter load taken from hot legs of 3-wire line



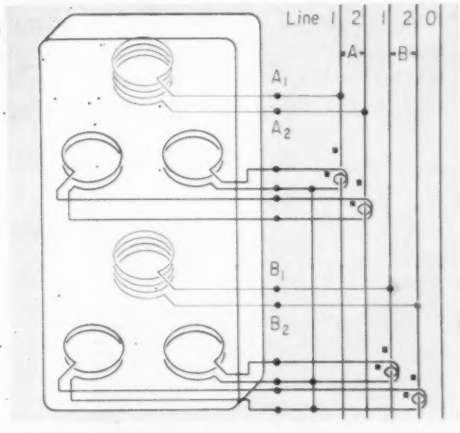
5 **3-WIRE 3-PHASE** circuit, or 3-wire 1-phase circuit from a 4-wire 3-phase system with a 2-element meter. Line 0 can be grounded wire



6 **4-WIRE 3-PHASE DELTA** circuit using a meter with a 3-wire and a 2-wire element. Neutral comes from grounded center tap of a phase



9 **3-WIRE 2-PHASE CIRCUIT** with a 2-element meter. The 4-wire, 2-phase circuit has the elements connected separately in each of phases



10 **5-WIRE 2-PHASE CIRCUIT** using a 2-element 5-wire meter and four current transformers. The current transformers aren't always required

Timely **practical ideas** to help solve

Now, Hypalon O-rings seal cylinder liners

Cylinder liners of ten engines at the Los Angeles sewage-treatment plant caused a tough sealing problem. The elastomer seal between the cylinder liners and frame or block casting of the engines didn't hold up.

The engines use a vapor-phase cooling process in which cooling water is circulated under 22 psi at 250 F. Steam is flashed from this water to utilize the cooking capacity of the heat of vaporization. Steam is used for solids digestion and space heating. Also, at higher operating temperature, engine efficiencies are increased.

But high operating temperature and steam of the vapor-phase process led to breakdown of the elastomer used to seal the cylinder liners, although this material had been successful in normal installations.

These O-rings must seal the circulating cooling water from the crankcase and the engine lubricating oil. Thus, they are subject to high wet heat and hot lubricating oil from the crankcase.

Rings of a commercial nitrile rubber were tried, but they heat hardened. Neoprene rings behaved in a similar way. Silicone rubber withstood oil and dry heat, but disintegrated under the wet heat of the engines. Three months was the maximum life of the best rings. Finally, Hypalon rings were tried. After 18 months, they still don't leak.

—Courtesy, E I duPont de Nemours & Co, Inc, Wilmington 98, Delaware

Valve handles for taps

I find that handles removed from pipe valves make excellent tap handles. They make it easier to (1) exert pressure at the start and while forcing the tap into the hole and (2) keep the tap straight at the start until it is deep in the hole. The tapered square hole on the valve handles make it possible to fit most taps.

A R Tanner Jr, *Poughkeepsie, N. Y.*

Easy does it!

While working as a boiler-repair mechanic, I was sent to a small manufacturing plant. Two mechanics from a rival company had been working for three days to remove a defective tube, without success.

The boiler was a sectional-header type and the bad tube was back of the front header. It was in the center of the tube bundle and had opened up flat as a sheet for about 3 ft.

Our competitor said it couldn't be removed without cutting out a lot of good tubes. That's when the owner called us in to tackle the job.

I had a weldor tie his torch to an 8-ft length of 1x2-in. pole. Setting his flame and striking his torch through the tube opening, the weldor made four cuts down the flat, open length of the tube. Then he made a circular swing. The flat part of the tube dropped off in four pieces and was easily fished out between the bottom tubes.

Next, I had the weldor make a cut in the top and bottom of the tube, ripping it for about 6 in. so it folded inside the tube hole easily. The rest was a cinch, as it had only to be cut at the rear and pulled out. All this was done so quickly that our competitor packed up and left without trying to collect three days' pay.

E J Duff, *Aurora, Colo.*

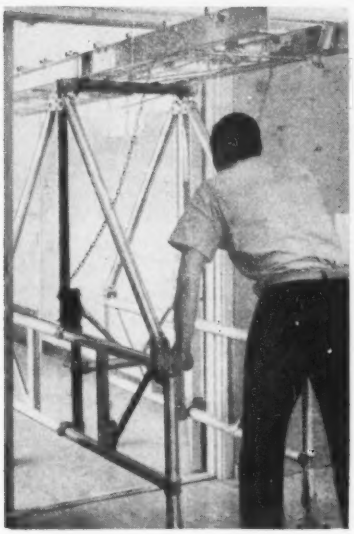
Grinding-wheel troubles?

Do unauthorized personnel use your grinding wheel to sharpen pencils, shape bits of wood or grind down large chunks of iron? If so, you probably have trouble keeping your stone clean, true and in shape to turn out a neat grinding job.

We cured this problem by removing the familiar "on-off" toggle switch that most grinders are equipped with. In its place we installed a key type switch. Result: Less maintenance and replacement since only authorized personnel have access to the keys to the grinder.

B A Crosson, *Cranston, R. I.*

your tricky design and maintenance problems



New telescoping platform

Here's a new telescoping, aluminum work platform for overhead spot maintenance at heights up to 30 ft. It's lightweight and rapidly assembled by one man. Legs are adjustable for uneven floors or stairways. Structure is only 29-in. wide for rolling through congested areas and it telescopes and folds down to roll through doorways, under trusses, pipes and conveyors. The unit separates into three components for convenient storage or transportation.—*Courtesy, Up-Right Scaffolds, Berkeley, Calif.*

Concrete to rescue

Like most shops and industrial plants we have a number of small drill presses in our plant. These machines are handy to use and are popular with the men. But, the men had one complaint: When drilling at full capacity, the press columns would bend and throw the drill out of square with the table.

We solved this problem by increasing the rigidity of these machines. The bottom of each column was plugged and filled with concrete, reinforced with pipes or rods. Our drill presses are now rigid. This idea may have other applications.

H KOSLOW, *Bronx, N. Y.*

What would you have done?

I was a machinist apprentice before World War I in Glasgow, Scotland. Saturday noon was the end of the long week, also payday. One week end an engine was to be overhauled after 5 pm on Saturday, in a mill three miles from our shop.

Two of our best journeymen machinists were selected because this mill was an important account. To make sure nothing went wrong, new piston rings had been made for the engine during the week. They were 20-in. diameter and were painted with a mixture of white lead and tallow, then carefully sewn in burlap to protect them during the trip to the mill.

The two mechanics collected their pay on Saturday noon, grabbed a bag of tools and the piston rings, then started a leisurely 3-mile stroll toward the mill. They had five hours, so to make the job as pleasurable as possible, they dropped into the first pub, had a drink and rested up a bit before dropping into the next pub.

They arrived at the mill at 5 pm, opened up the steam engine and pulled the large piston. But, after removing the old piston rings and cleaning the grooves, they couldn't find the new rings. They looked at each other horrified. One man quickly started retracing their steps, but after a few hours came back empty handed. By then they were both sober—and how! Being mechanics of the old school, they quickly peened the old rings to expand them. Then they placed them on the piston and closed up the engine.

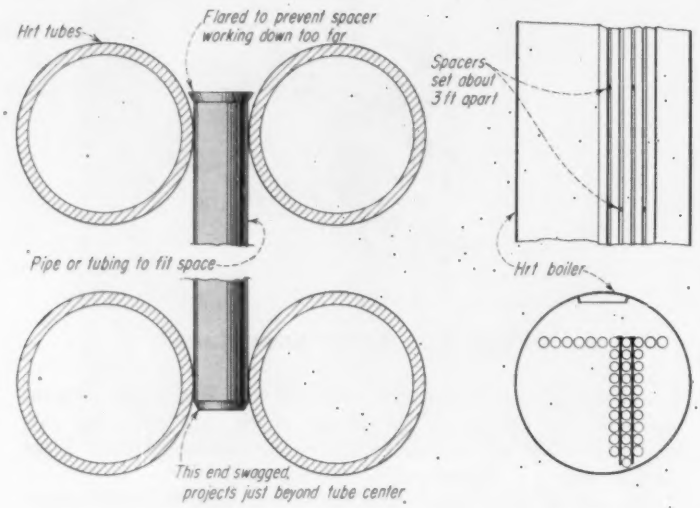
All day Sunday was spent retracing their steps again, but no rings. On Monday and Tuesday they were back on the job in the shop—but very much on edge, fearing that someone would show up in the front office any minute with the lost rings.

Then, on Wednesday, a visitor showed up with the shop manager. This was *it*. The two culprits froze stiff. Yup, the visitor and boss were looking for them. The axe seemed to be hanging heavy.

But when the boss pointed them out, the visitor stuck out his mitt and shook hands. Pumping their arms and smiling from ear-to-ear, he congratulated the mechanics for the excellent job they did on his engine. He said that steam consumption had dropped so much that his firemen had no more trouble keeping up steam and his fuel bill was way down. Then, for good measure, he pressed a generous tip into each mechanic's hand. They just stood there with open mouths. What would *you* have done?

W GEDDES, *Montreal, Que.*

Turn page for more Practical Ideas ►

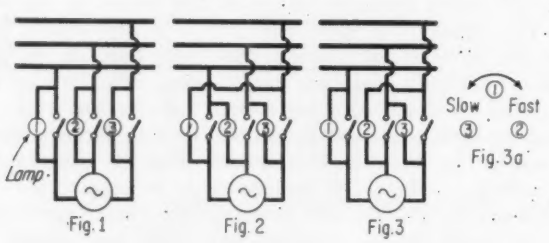

Hrt tubes
Flared to prevent spacer working down too far
Spacers set about 3 ft apart
Pipe or tubing to fit space
Hrt boiler
This end swaged, projects just beyond tube center

No more scale plugging our hrt boiler tubes

We had a problem with our hrt boiler tubes bowing and trapping scale that was dislodged from chemical feeding. The scale continued to pile up between washouts. We had to stop that condition, but fast!

Problem was solved by placing spacers about 3 feet apart between tubes, as shown in sketch, above. One end of spacer tubes were flared to keep them from working down. Bottom end was swaged to help force the spacers down between the tubes. Reason we spaced them about 3 feet apart was to keep from upsetting the boiler's natural circulation. Now only a few large pieces of scale hang up. These are easily knocked through when boiler is opened for cleaning.

W E WALL, *Pendleton, Ore.*



You can synchronize alternators with lamps

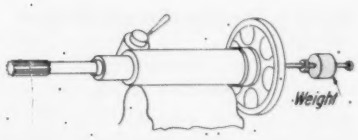
The maximum voltage across any lamp is always 2.83 times the nominal line voltage. Suitable transformers are usually required in practice. In Fig. 1 and 2, above, one lamp only can be used, but all three are necessary in setup shown in Fig. 3.

Fig 1. With this circuit, when the generator is in phase with the bus there's no potential across the switch contacts and the lamps are out. In the middle of the "out" period the switch can be thrown. This is not as easy to estimate as method shown in Fig. 2.

Fig 2. When the generator is in phase with the bus there's maximum potential across the lamps, thus, the lamps are at their brightest. The "brightest point" at which the switch should be made is easier to see than the "dark point" of Fig. 2. In both these arrangements the lamps switch on and off together.

Fig 3. In this circuit the lamps will flash off and on in succession as the generator approaches synchronization. If the lamps are arranged as in Fig 3a, the apparent direction of rotation of the flashes will indicate whether the incoming alternator is running fast or slow. At synchronism, lamp 1 is out and lamps 2 and 3 are equally bright.

P O HOBSON, *Concord, Calif.*



Tool knocker-outer

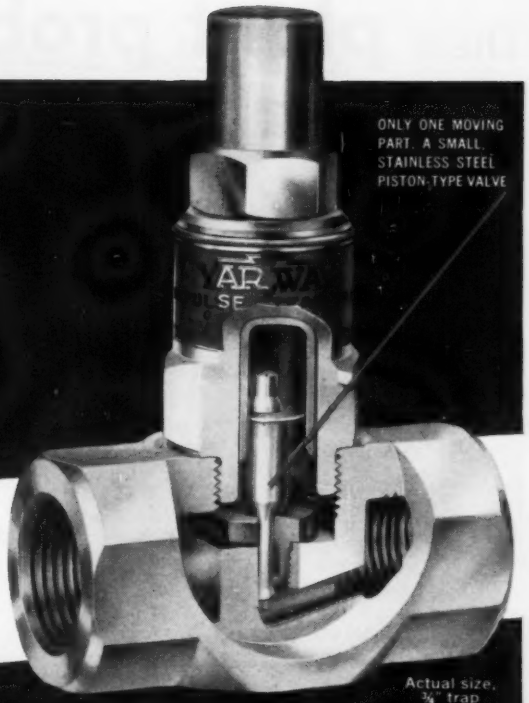
We often turn out sleeves, bushings or shaft collars on our maintenance-shop lathe. This work requires much changing of drills and reamers in and out of the tailstock. Previously, to remove a tool we had to crank the tailstock back until the screw knocked out the tool.

To speed up this work we drilled a small hole through the tailstock screw and made a ram rod with a sliding weight, sketch. Now, the tools can be removed without cranking back the tailstock screw. We also use this hole to blow chips and dirt out of the tailstock. It works fine.

H KOSLOW, *Bronx, N. Y.*

My biggest boner . . .

Please turn to page 172



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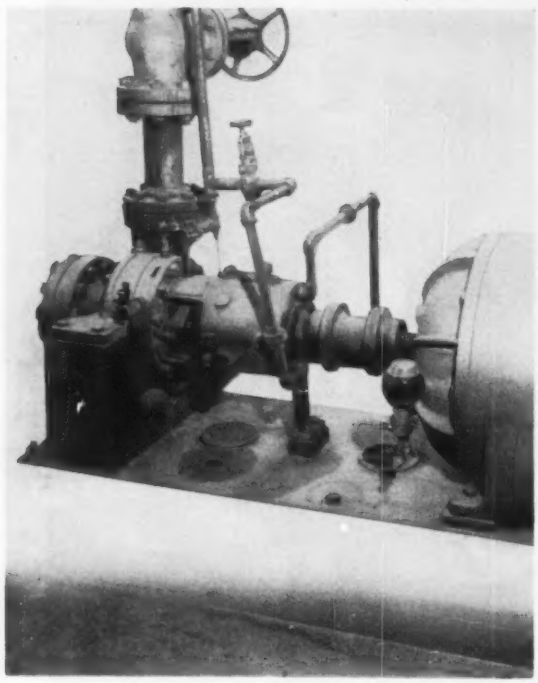
Write for free bulletin "The Why and How of Steam Trapping."

These **plant problems** could well be yours...



The problem

Do our centrifugal pumps need low-flow recirculating lines?

I'm responsible for the pumping equipment in a chemical process plant. We have a large number of centrifugal pumps in a variety of sizes, handling everything from corrosive chemicals to ordinary cooling water. Recent changes in our process now have some pumps running pretty close to shutoff for periods of several hours or more. I'm afraid we may be headed for trouble. Just how long can a centrifugal pump safely run at shutoff head with the discharge line closed? How far down can flow be throttled? Do we have to install low-flow recirculating lines? Have readers had similar experiences?—*MH, August* POWER

The solutions

Don't run centrifugal pumps near shutoff

There are three reasons why a centrifugal pump should not be operated near shutoff: heating, radial thrust and wear. This is the usual order of importance, although in each case it's decided by the type of service and the pump characteristics.

Heating can be a dangerous problem on any service, but it's of greatest concern on boiler feed or other high-temperature water service. Temperature of liquid at entrance of the first stage impeller must be kept below its boiling point for the pressure at that location.

Energy transferred through the pump coupling results in useful delivery of water and in wasteful heat. At low flows, useful work is negligible and waste heat is enough to boil liquid within pump. This quickly fills pump with steam or vapor. These vapors are poor pumping mediums which don't give proper lubrication to close-fitting clearance, and seizures result. But this can be prevented by permitting some minimum amount of liquid to circulate through the pump continuously. Exact amount depends on working conditions. Since one brake horsepower equals 2545 Btu per hr, temperature rise can be calculated from:

$$F = \frac{2545\ (\text{bhp})}{\text{gpm}\ (8.345)\ 60} \quad \text{or} \quad F = \frac{5.09\ (\text{bhp})}{\text{gpm}}$$

The bhp and weight of water can be corrected for temperature, but one offsets the other. Permissible temperature rise can be taken from a steam table. Let's assume that boiler feedwater is taken from an overhead storage tank at a temperature of 259 F. With a suction pressure of 40 psia, the steam table shows that water temperature can rise to 267 F before flashing occurs. This leaves a margin of 8 F. If the pump calls for 100 bhp near shutoff and is delivering 75 gpm, the temperature rise is 5.09 times 100, divided by 75, or 6.8 F. So from the standpoint of heat rise alone, the pump can operate indefinitely at the rate of 75 gpm without flashing.

The overall subject of heat rise is a broad one. And each pump design must be treated independently. But in general, pumps handling hot liquids should not be run with a closed discharge. When handling cold liquids, the time can be extended to minutes or even hours. If pump has a balancing drum, leakage may be enough to keep the temperature within bounds. Boiler-feed pumps call for a minimum flow line from pump discharge back to the heater or other suction source. Never connect a recirculation line from discharge to suction. This merely adds additional heat to the water going around and around.

Radial thrust isn't usually high on pumps enploying circular casings or diffusers. But it is often a problem with volute type pumps. High radial thrust induces bending moments that promote shaft fatigue failures. It originates in the volute and is maximum at shutoff.

L-p pumps and pumps with narrow or small-diameter

...Here's how *Power* readers would tackle them

ROBERT MARKS, Assistant Editor

impellers can frequently run all the way to shutoff without shaft failure or excessive wear. Wide impellers, such as are found in large, horizontally split circulating pumps, create so much radial thrust that shaft life is reduced to a few months when operating at capacities less than 40 to 50% of capacity at peak efficiency.

Overhung impellers, such as are used in refinery pumps, and close-coupled motor pumps also experience high radial thrust and shaft deflection. This causes excessive wear at the clearances and contributes to early mechanical-seal or packing failure. Problem is solved by designing casing with two volutes spaced 180 deg apart. In 2-stage pumps volutes can be rotated 180 deg to achieve the same effect. Another solution is to install a run-around pipe from pump discharge back to pump suction.

Wear takes place when handling abrasives in suspension. If pump discharge is wide open, liquid is handled only once. With a nearly closed discharge, liquid is recirculated over and over and much of it is forced through the wearing rings. With an open impeller the liquid leaks from high-pressure tips of impeller vanes, back down between vane's edge and the adjoining shroud or suction pipe face. Abrasive particles rapidly wear away the mating faces. Even clear liquid recirculated in the volute has high-speed turbulence and re-enters impeller exits. This water impingement can deteriorate soft metals.

Centrifugal pumps operate smoother and longer if capacity corresponds to that at peak efficiency. Additional power used up often represents money well spent since maintenance and downtime is greatly reduced.

E H FREY, *Phillipsburg, N.J.*

Look out for deflection and shaft whip

If centrifugal pumps are run at shutoff, heat buildup, deflection and shaft whip are problems which can cause mechanical failures. At low flows, on pumps handling 500 gpm or less, the problem is almost entirely deflection and shaft whip. Heat buildup can cause vapor flashing and cavitation; and if carried far enough, particularly on semiopen impellers, it can cause binding of parts.

Deflection and shaft whip. I assume your pumps are the volute type. In these running deflection is highest at shutoff and remains high until at least 25% of normal capacity is reached. Deflection probably varies between 0.002 in. and 0.020 in. for most pumps operating in this range of low flows. Deflections over 0.005 in. can produce: (1) Excessive packing and sleeve wear (2) Severe mechanical-seal wear, particularly under chevron packing rings. If deflection is bad enough and accompanied by whip, one of the wearing faces, such as the carbon ring, will fracture (3) Shorter bearing life because of heavier stresses from deflection or shock failures. (4) Seizing of running clearance joints, especially at the wearing rings.

Since there are so many factors involved, *MH* should discuss this problem with the company that manufactured his pumps. Heat buildup problems can be taken care of by a very small amount of low-flow recirculation. But it's questionable whether his pumps will stand heavier deflection at the lower flows. If the pumps are over five years old, they may have overhangs that are too long and shafts that are too small. In this case the pumps may have to be replaced with a newer, heavier design that's better suited for operation near shutoff. This is required more and more as chemical plants shift from batch to continuous operation.

R D NORTON, *New York, N.Y.*

Low-flow bypass cuts pump maintenance

Let's assume *MH* has all or some of the following types of pumps: end-suction, top-discharge, single-stage, single-suction process pumps; horizontal split-case, double-suction volute pumps and multistage high-head pumps for such services as boiler feed. There are at least five valid reasons why these centrifugal pumps should not be operated at shutoff or very low flows.

(1) Radial unbalance develops when the impeller discharges into a single volute. These unbalanced forces react on the shaft, causing it to deflect. If deflections exceed normal operating ring clearances, the rotor will contact stationary members, causing seizure, or at least an increase in running clearances.

(2) Heating can be held to a 15 deg rise by circulating 30 gpm of liquid pumped for each 100 bhp at shutoff. This flow must be returned to the suction source and not just pump suction. In cases where radial thrust is the problem, minimum flows for a specific temperature rise may have to be increased so pump can handle resultant radial thrust. One other factor to consider is effect of higher temperature on chemical behavior of the liquid pumped. This may call for more expensive pump materials and it may affect the chemical process itself.

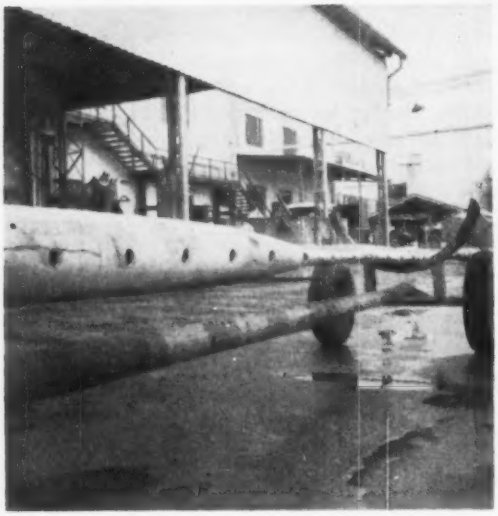
(3) Maximum turbulence is encountered at low flows. So a process pump on slurry service needs an adequate bypass to increase pump life and reduce upkeep.

(4) Erosive action is at a maximum when the liquid flow is minute. Let's assume that liquid pumped has corrosively attacked the pump because of the increased temperature at low flow: The parts subject to attack are washed clean by erosion and carried away, leaving parent metal exposed to further attack.

(5) Pump discharge valve is the last trouble spot. Though it's supposed to be fully closed, there will probably be some slight leakage across valve. This minute flow at a high pressure drop will cut or wire draw the valve seat. Valve repair or replacement is then needed.

J R BROCE, *Harrison, N.J.*

Turn page for new problems ▶



The problem

What caused our feedwater nozzle to fail?

During an emergency overhaul to our No. 6 boiler, we found the feedwater pipe had collapsed for about one-half its length into the interior of the steam and water drum.

Rated capacity is 110,000 lb per hr at 720 psig and 735 F. Boiler has automatic combustion control with a 2-element feedwater regulator. Feedwater pipe, above, is 6-in. OD with thirty 1¼-in. holes.

In the last two years the feedwater pipe has failed three times. First time there was a crack in the welding; second time it moved right off the support brackets. Before each failure it was hard to keep boiler-water concentrations down to desired level. But this time there wasn't any such indication.

What caused this pipe to collapse? Does the rise in boiler-water solids have any significance? How can we prevent another failure? Any suggestions will be gratefully received.—*DM, August* POWER

The solutions

Want some help on plant problems? Send us any of your design and operating headaches. We'll put *Power* readers to work on them

Keep drum water level above feed pipe

The feedwater distributor pipe collapsed because of a form of water hammer. With the boiler hot and the feedwater valve closed, the distributor pipe at least partially drains. Part of it is then filled with steam. When the feedwater valve is opened, incoming water condenses the steam and creates a vacuum that collapses the pipe. The feedwater distributor pipe will drain if it is located just a little above water level. The pipe will then contain steam whenever there isn't any water being fed to the boiler. This may occur during startup or while the boiler is on a hot bank.

This form of damage can be prevented by locating the pipe in the drum so that it is submerged at the lowest permissible water level. If this isn't possible, turn the pipe so that the holes are facing up. Nozzles can then be inserted in the holes to direct feedwater in the desired directions. An alternate solution is to put the feed pipe in a trough and allow water to spill over the edge. But the trough must be tight, otherwise the water hammer will reappear.

A RUCH, *Port Washington, N.Y.*

Water hammer is cause of *DM*'s trouble

DM's problem recalls an experience some years ago. On a similar size boiler the feed pipe failed within weeks after boiler was placed in service. A similar rise in solids took place. But this failure was caused by active corrosion. It was traced to a tube failure in deaerating heater's vent condenser. This had allowed oxygen-rich feedwater to enter the boiler. So any sudden increase in boiler-water solids should be investigated.

Careful examination of the photo indicates an entirely different kind of failure. Feed pipe was flattened by a terrific force as though placed under a pile driver. The only force capable of such damage is water hammer.

Here's how I would explain this failure. The 2-element feedwater regulator consists of a water-level regulator, usually a thermo-expansion type, and a flow-metering element. Upon sudden surges in steam flow the metering element will override the thermo regulator. Under stable conditions the thermo regulator does all the work. So the flow-metering element can be inoperative without immediate detection.

I suspect *DM* has a relatively stable steam load. Suddenly, steam demand shoots up. The steam pressure drops, combustion control increases firing rate and the water level rises. Then the thermo regulator shuts off water flow completely just at the time the boiler needs more water. The flow-metering element has failed to override the thermo element. Water in the steam drum is adequate for perhaps five minutes. During this period of no flow through the economizer, steam begins to generate in the economizer at 800 psi, the feedwater pressure.

Finally, water level in the drum drops and the thermo

element slams wide open. Water in the feed line is then propelled into the boiler at terrific velocity by the expanding steam in the economizer. As it strikes the capped end of the feedwater pipe, the terrific shock of water hammer occurs. The pipe segments between holes are weakest and are forced outward. Crack shown on left of photo is also between segments.

I believe a thorough overhaul of the feedwater regulator or complete replacement if obsolete will stop *DM*'s troubles with the feedwater nozzle.

W J STEINERT, *Fresh Meadows, N.Y.*

Check feedwater regulator carefully

Feedwater should be supplied at the same rate as the steam is evaporated. This means that the water level in the steam and water drum has to be controlled at essentially the same level under all load conditions. As long as water evaporates, the feedwater-regulating valves will never be fully closed. Check your water level indicator and make sure that water level in the drum doesn't change more than one in. If it fluctuates more than this, it's a sign that your feedwater regulator is not working properly. Feedwater-regulating valve may then close or open suddenly producing pulsations and vibrations in the feedwater pipe.

It's also possible that drum water level dropped below holes in the feedwater pipe. Since feedwater temperature is much lower than saturated steam temperature, you may then get sudden steam condensation in the drum with resulting heavy vibration. So make sure that drum water level is well above the feedwater pipe. As long as material of the feedwater pipe is not austenitic, the boiler solids do not have much significance to this problem.

O W BOESE, *Germany*

Watch solids in boiler water carefully

DM's rise in boiler-water solids should be carefully watched. If suspended solids in the boiler are too high the boiler water will foam. Foam develops when the water film around the steam bubble, as it is generated at the heating surface, becomes stabilized by dissolved and suspended solids in the water. In other words, the bubble skin becomes tough and doesn't break readily when the bubble emerges. When rate at which foam is delivered to the drum exceeds rate at which it is destroyed, froth eventually fills the drum. This leads to carryover of water with the steam and certainly contributes to the trouble experienced with the feedwater nozzle.

High boiler-water solids occur because of improper water treatment or insufficient blowdown. Oil must be kept out of the boiler by coagulating and filtering any condensate that is contaminated. Certain antifoam chemicals are helpful in preventing foaming.

Foaming can be reduced by using blowdown to reduce concentration of solids in the boiler. Solids concentration in *DM*'s boiler should not exceed 2000 ppm. Continuous blowdown equipment should be used to maintain these limits and to conserve heat present in the blowdown.

DON KELLAND, *New York, N.Y.*

Your December problems

What's wrong with the intercooler on our new 2-stage compressor?

We have two new identical 4200-cfm 2-stage air compressors. Air intake for each is outside. Outlet air pressure is 105 psi at a temperature of 75 F. Cooling water enters the intercooler at a temperature of 70-75 F. It passes through heat-exchanger tubes and is raised about 15 F. On warm days with high humidity, we get about ten gph from the intercooler trap and about the same amount from the aftercooler trap on machine No. 2.

But on machine No. 1 we only get about one pint of water per hour from the intercooler and 12 gph from the aftercooler with some water passing on to receiver tank with the compressed air.

A new intercooler water separator was installed on this machine and the whole system checked by service engineers. Pressures, temperatures, intercooler construction, and location of air intakes are identical. Have any POWER readers run into a puzzle like this? How can we track this trouble down?—*CJZ*

How can we improve our gravity condensate-return system?

Condensate from the heating system in many warehouses and office buildings is fed into condensate receiver tanks at each location. It's then pumped into common gravity-return lines leading back to main condensate receiver at the powerhouse. Both steam and condensate lines run underground with manholes at each building.

Two separate branch lines, following the general run of the ground, slope toward the powerhouse and are joined in a Y connection some distance away. Condensate apparently collects at this point and comes back to the receiver in tremendous surges with an alarming amount of vibration. One suggestion is that we convert the return system to vacuum operation. Will this solve our problem? What is the best way to make this change in the condensate system?—*JHS*

Sit down right now and answer one or both problems. We'll pay extra for answers with photos or sketches.

Your page for comment

BOB BELLAS, Associate Editor

Gas attack

Marmy bu-bued in July ("Marmy's space ship," POWER, July 1958, p 132) in saying he used illuminating gas or acetylene to inflate the balloons. Neither gas would provide enough buoyancy to lift the rubber, let alone the nut and fishline.

E D HAIGLER, *Hatboro, Pa.*

. . . Either natural or manufactured gas will lift a balloon very easily. Acetylene's specific gravity is 0.9, has little lifting potential. But it will lift an object if the balloon is large enough. Pioneer French balloonists used hot air or a crude form of water gas.

Situation is similar to wood floating on water—how much it can support. Green wood's specific gravity ranges from 0.8 to 1.33. Obviously, woods that are denser than water will sink; those that float will support weight or there would be a lot of lumberjacks walking on the bottom of the river.

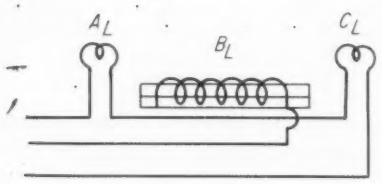
Basic problem here is how big does the balloon have to be? How big, in Marmy's case can be determined if we know the nut he used weighed ¼ lb, heavy twine weighed ½ lb and the balloon's weight was 1 lb. Total weight to lift would then be 1¾ lb. I did some calculating (figures available on request) and found that Marmy could have done the job with 54.2 cu ft of illuminating gas in a 4.7-ft dia balloon. If he used acetylene, the balloon's diameter would have to be 6.5 ft—which it undoubtedly was.

MAX MARSHALL, *Island Park, N. Y.*

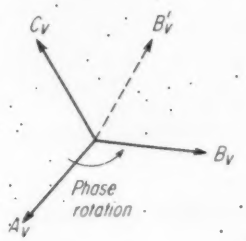
. . . Illuminating gas has specific gravity of 0.4, would have tough time cutting the mustard. With acetylene—specific gravity 0.9—it would be impossible. Just to check, I filled a balloon with acetylene. Gas wouldn't support balloon's weight.

Next time, Marmy should be near a heliarc welding rig or, better yet, he might want to invert a 5-gal jug over a little sulfuric acid and aluminum.

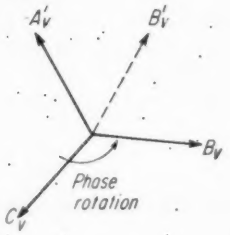
S W GREENE, *Anderson, Ind.*



Sequence indicator connections



Voltage vector (a)



Voltage vector (b)

About phase

Assistant Editor Peach's article on phase sequence (*Plant Electrical Fact File*, POWER, September 1958, p 116) was very good. However, I believe an explanation of the sequence indicator with the aid of voltage vector diagrams, shown above, would be a helpful addition to the article.

Consider the Y-connected apparatus having two resistive and one inductive load energized by a 3-phase balanced voltage with phase sequence *ABC*. Due to inductive reactance of coil B_L, the current through it lags impressed voltage by nearly 90 degrees. This causes effective emf to be distorted timewise as indicated in vector diagram (a). B_V is shifted to position B^1_V. Due to this shift, the currents through B_L and C_L are more nearly in phase and the 2-phase current is approaching single-phase conditions. Since the algebraic sum of the three currents is zero, current through C_L must be something less than the current though A_L, and lamp A_L will burn brighter than lamp C_L.

When phase rotation is reversed as at (b), the same conditions occur, but lamp C_L will burn brighter than lamp A_L and rotation is *ACB*. As apparatus leads are identified, phase sequence of the power source is easily determined.

E G GARDINER, *Red Deer, Alberta, Canada*

(Advertisement)

Why Every Steam Heated Unit Needs its Own Steam Trap

. . . the theory, practice and proof of "unit trapping" for top temperatures

Using an individual trap for each steam heated unit, including each separate coil, chest or chamber of a machine—pays off for the user. Here are just two examples:

1. On a creamery dryer

Drainage Method	*Air Temperature*
Restricted Blow-thru	250°
Group trapping (1 trap for 8 coils)	225°
Armstrong Unit Trapping (8 traps—1 for each coil)	**309°**

2. On a platen press

Drainage Method	*Processing Time*
Restricted Blow-thru	50 minutes
Group Trapping	35 minutes
Armstrong Unit Trapping	**25 minutes**

Why Unit Trapping Works Best

It is reasonable to assume that no two steam heated units will have *identical* condensing rates. Even the slightest difference in rate will cause a difference in steam pressure drops through the units. Here's where the trouble starts. Condensate from each unit may flow to the trap. But, what about air and other non-condensibles in the system? A difference in pressure drops too small to be indicated by an ordinary pressure gauge will permit backflow of steam from the higher pressure units to the lower pressure units. This backflow of steam may even impede flow of condensate from the lower pressure unit to the trap . . . and it will definitely impede or block off flow of air to the trap. The result is sluggish heating, reduced temperatures, reduced output, fuel waste and increased possibility of corrosion. Figures 1, 2 and 3 diagram the action.

Unit Trapping Not Costly

No engineer wants any more mechanical devices in his plant than are absolutely necessary. But, the moderate additional cost of using two or more small traps, instead of one big one, is saved over and over again in improved efficiency.

If the traps are Armstrong, maintenance is no problem. And users frequently tell us that Armstrong traps outlast others two and three to one.

Steam traps usually represent a fraction of 1% of the cost of the equipment they drain. Does it make good sense to lose 10% or more of equipment capacity to save a few dollars on traps?

Why not test Armstrong unit trapping in your plant. If you are not completely satisfied with the results you can return the traps for a full refund of the purchase price. There is little to lose—lots to gain. Call your local Armstrong Factory Representative or Distributor, or write **Armstrong Machine Works, 8123 Maple St., Three Rivers, Mich.**

ASK FOR the 44-page Steam Trap Book and reprint of article on Unit Trapping.

801ST

How Different Condensing Rates Can Slow Production

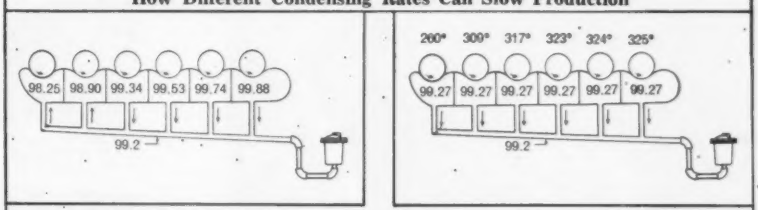


Fig. 1 This is a 6-roll ironer shortly after it has begun operating on 100 psi steam. When cold, wet material passes over chest 1, steam condensing rate is high and pressure drops accordingly. The pressure drop in chest 2 will not be as great, and so on down the machine as the material becomes progressively hotter and drier. Average pressure in the chests then is 99.27 lbs., and drain header pressure is slightly less, about 99.2 lbs. Under these conditions, steam from drain header enters chests 1 and 2 (as indicated by arrows at side of drain lines) because of pressure difference. Though condensate from chests drains by gravity, air can't leave chests countercurrent to incoming steam. Fig. 2 shows what happens next.

Fig. 2 This is the same 6-roll ironer after it has been operating a while. Air has accumulated in chests 1 and 2, reducing condensing rate and decreasing pressure drop. This process repeats itself down the line until pressures are as shown—that is, enough air will accumulate in each chest so that condensing rates and pressure drops of all chests will be about equal. The net result is shown in chest temperatures which are actual pyrometer readings taken on a 6-roll ironer, drained by a master trap, in a Chicago laundry. The laundry was making 337.9°F steam, but getting an average of only 309.6°F from the ironing surfaces, necessitating slow operation and frequent reruns. Then they tried Armstrong unit trapping—see Fig 3.

How Unit Trapping Prevents Trouble

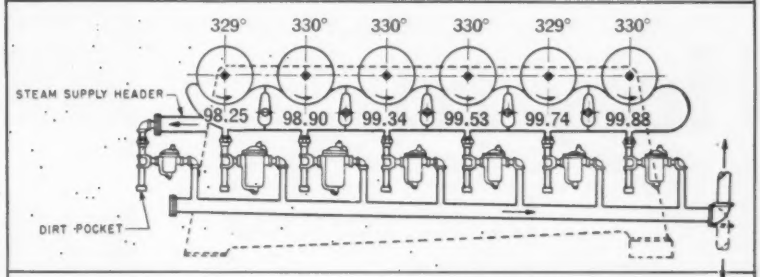


Fig. 3 This is the same 6-roll ironer, now unit trapped. Temperatures shown are also actual pyrometer readings—the average of 329.6°F is 20° higher than with group trapping. This is because air is continually removed from each chest into the drain header, and cannot get back into any chest.

ARMSTRONG STEAM TRAPS

1—Put work on hard flat surface; place foot and hand as shown

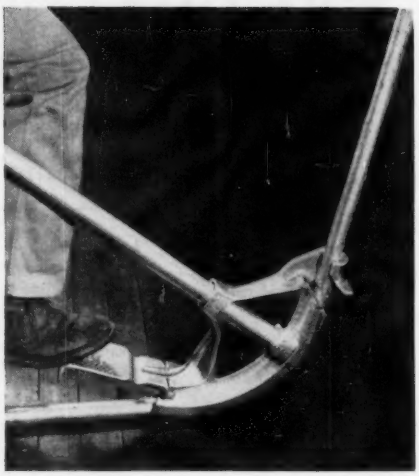
How to

bend conduit

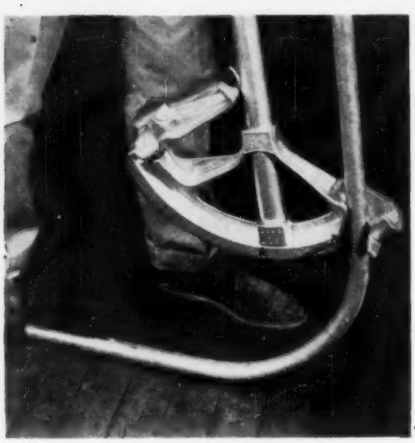
At long last, here's an easily operated, portable, one-piece hand tool for bending 1-in. Sheraduct and other types of rigid-steel conduit. It can also bend 1¼-in. X-duct Junior metallic tubing. Bender has a "power jack" booster step to help operator apply extra force needed to make tough bends.

It's the only tool of its kind for on-the-job bending of 1-in. rigid-steel conduit and 1¼-in. electrical metallic tubing. Manufacturer states that cost of bender is soon absorbed because of savings in elbows and couplings needed for fittings with straight tubing. Tool does away with bench-mounted bending equipment.

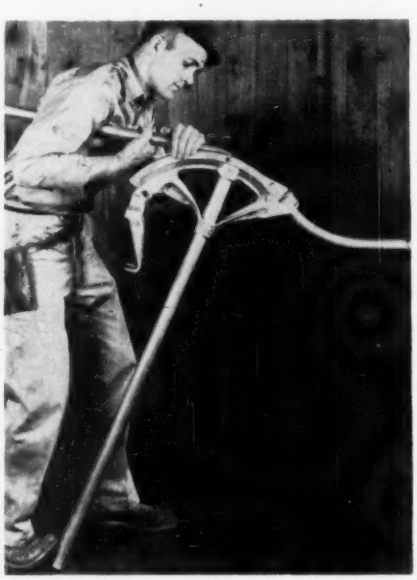
Other features are an integral back-pusher groove to true up and straighten bends, a short radius arc for shallow slabs and narrow partitions and a safety collar for thread protection. Hook portion of bender has an out-rigger stabilizer for a firm footing.—*Courtesy, National Electric Products Corp, Pittsburgh, Pa.*



2—Apply heavy foot pressure for full 90-deg arc



3—After bend is complete, remove tool as shown



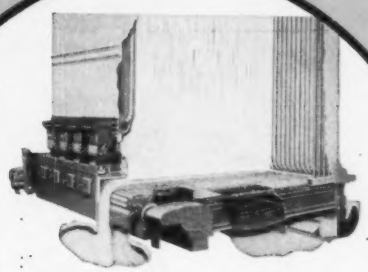
4—Here's an easier way to make S bends quickly

USE DETROIT SPREADER STOKERS TO BURN SOLID FUELS WITHOUT EXPENSIVE PREPARATION

DETROIT ROTOGRATE • ROTOSTOKER • ROTOSTOKER (TYPE C-C)

HIGH ECONOMY AND AVAILABILITY • LOW MAINTENANCE

1



DETROIT ROTOGRATE

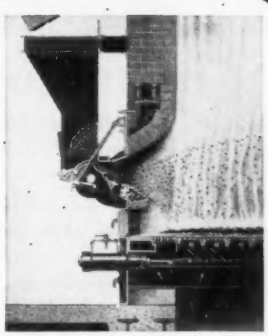
Original spreader stoker with forward moving grates that discharge the ash at the front. Our long experience has contributed to many exclusive refinements and features of design. Proven superiority with hundreds installed here and abroad. For capacities up to approximately 400,000 pounds of steam per hour.

Detroit Stokers burn any Bituminous Coal or Lignite without special preparation. Commercial sizes ranging from 3/8" x 0" to 1¼" x 0" are ordinarily used. High burning rates without clinkering difficulties. Also many refuse fuels including wet bark, hogged wood, bagasse, etc. are burned separately or in combination with coal; efficiently and without smoke.

Widely fluctuating loads are easily handled. Parasite power is negligible. High overall efficiencies at all capacities are assured. Maximum availability and very low maintenance.

Buy "Detroit"—They are "the most".

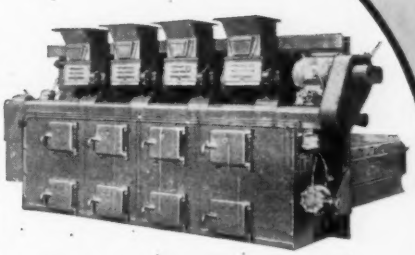
2



DETROIT ROTOSTOKER

For small and medium size units. Power Dumping, Hand Dumping or Stationary grates to fit the furnace provide desired capacity under full automatic control.

3



DETROIT ROTOSTOKER (TYPE C-C)

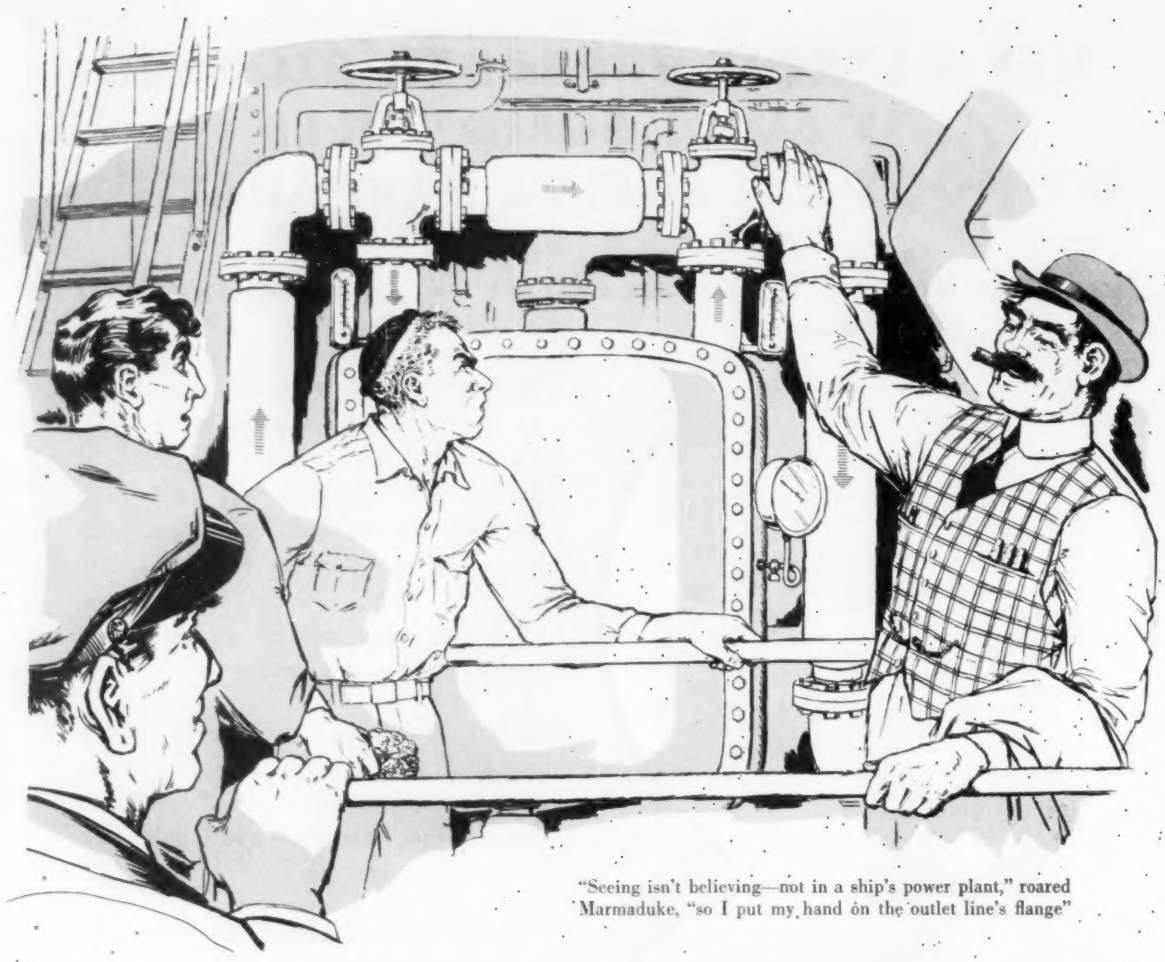
Continuous cleaning type particularly suited to highly fluctuating loads. Many sizes for capacities of 5,000 to 75,000 pounds of steam per hour. Reciprocating grates discharge ash at front. No basement is required.

DETROIT STOKER COMPANY

MAIN OFFICE AND WORKS • MONROE, MICHIGAN

District Offices or Representatives in Principal Cities

WRITE FOR BULLETINS ON THESE MONEY SAVING STOKERS



"Seeing isn't believing—not in a ship's power plant," roared Marmaduke, "so I put my hand on the outlet line's flange"

Marmy's touch system

Two years of active duty at the U.S. Merchant Marine Academy during World War II brought me in contact with thousands of cadet midshipmen. Today, many of them hold important jobs, both afloat and ashore.

Receiving letters and visits from former cadets makes life interesting here on POWER. One engineering cadet I remember was Bill McCumber, class of 1943, who writes from San Francisco that he now represents a boiler firm. Bill ends his note by saying that if Marmaduke made a good-will tour to the West Coast today he'd probably stay out there because of all the consulting opportunities for a topnotch engineer.

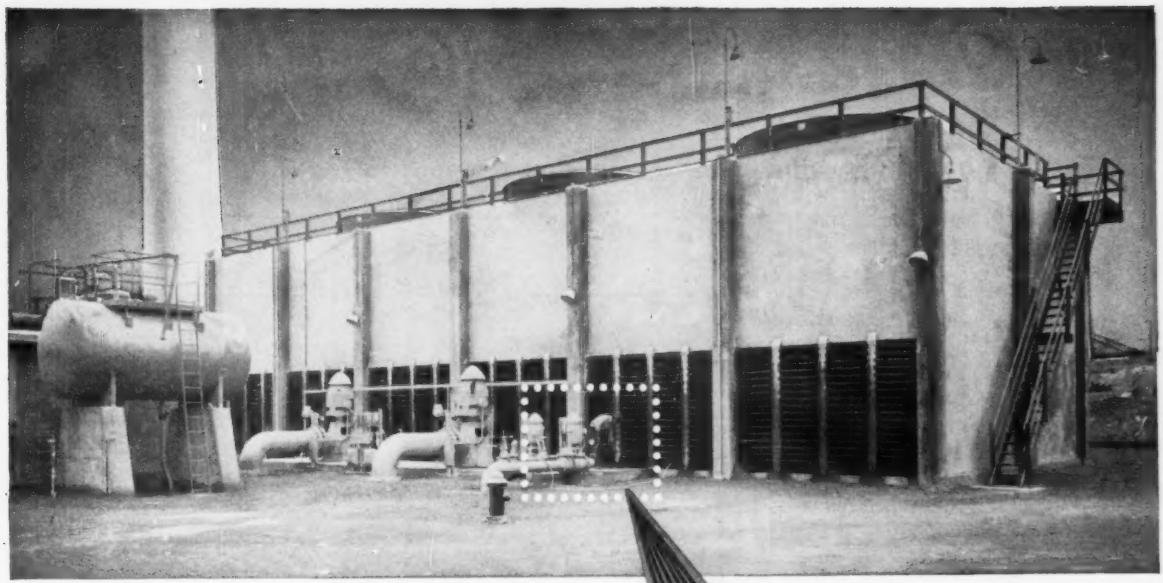
A half hour later I was climbing the rickety stairs leading to the old consulting engineer's office above O'Houlihan's Machine Shop & Engine Works. The noise of flapping leather belts from the machine shop was suddenly drowned out by ferocious snarls from above. It sounded like wild monsters in a death struggle. Climbing cautiously, I had visions of a free-for-all in Marmy's office. But a glance through the open door set my mind at ease.

There was the old gent leaning back in his swivel chair, feet propped up on his roll-top desk, sound asleep and snoring his head off. For the first time since I could remember, the ancient cantankerous goat was without his usual assortment of waterfront shipmates. This seemed weird.

Just then the phone rang. The snoring stopped. Marmy opened his starboard eye, swung it in a wide arc around the room, as you would a spotlight, then suddenly sat up. His right arm shot out, yanked the ear piece off the hook and he yelled, "WRONG NUMBER." Then he slammed down the receiver with a crash that must have busted the unhappy caller's eardrum into little pieces. Yawning leisurely, the old boy leaned back into his former position and closed his eyes again.

"Here's a reader who says a crackerjack consultant like you would never return to New York if you visited the West Coast", I said quietly, "because you'd find so much business out there."

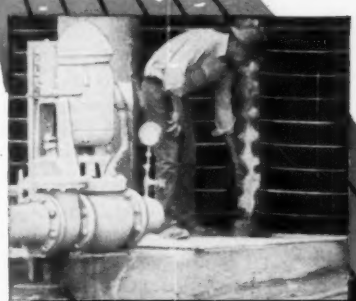
Nothing happened for a second. But then Marmy opened both eyes wide and slowly sat upright. Fishing a piece of rope yarn from his vest pocket, he lit it, then roared in his foghorn voice: (*Continued on page* 208)



Unusual Cooling Tower

gets proven *Nalco* protection

This unusual cooling tower was built for the Riverside Cement Company at Oro Grande, California. The advanced design provides for concrete exterior walls which support and enclose fan units and redwood interior cooling vanes . . . The entire "working sections" of the tower can be repaired or replaced without affecting the structural strength of the shell. Nalco System Treatment protects this cooling system against scale and corrosion — has protected it effectively since it was first put in operation over two years ago. You can get the same complete water treatment protection, promptly, from Nalco. Write for details.



Method of feeding Nalco stabilizing treatment to this system is simplicity itself. Formula is supplied in ball form. Once each shift a perforated tube suspended in the tower basin is filled with balls which slowly dissolve in the cooling water.

NATIONAL ALUMINATE CORPORATION
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CANADA: Alchem Limited, Burlington, Ontario
NORTHWESTERN UNITED STATES, HAWAII and ALASKA:
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WEST GERMANY: Deutsche Nalco-Chemie GmbH
SPAIN: Nalco Espanola, S.A.

Reports from the field

What's happening in power and what it means to you

You can broil a steak on this latest red-hot motor

An electric motor that runs efficiently while hot enough to quick-broil a steak; a panel to produce heating, cooling and lighting; an ultrasonic sink—these are projects currently undergoing research, announces Westinghouse Electric Corporation.

The "red-hot" motor will find many special applications in our high-temperature age. Capable of operating when literally *glowing* with heat, it's insulated with nonorganic compositions, related to house bricks, concrete highways and window glass. Its phase and slot insulation is flexible sheet material made of glass cloth and large mica flakes bonded with phosphate. The silver wire is insulated by covering it with glass fiber, then impregnating it with powdered mica in a phosphate solution. After winding, the motor is impregnated and potted with a liquid slurry made of phosphate and silica.

The motor has been operated at temperatures up to 1200 F. At 950 F, hot enough to grill a steak in seconds, it has operated for several thousand hr without insulation deterioration.

Wall and ceiling panels for year-round conditioning and lighting combine thermoelectric refrigeration and electroluminescent lighting. First experimental model revealed by Westinghouse is composed of solid-state materials, has no moving parts. It gives off as much light as a 25-w bulb, and produces your choice of household-refrigerator temperature or 130 F at the flick of a switch.

The ultrasonic sink, which may show up in labs, as well as kitchens, of the future, has been improved with the development of a more efficient ultrasonic transducer. Cleaning by ultrasonic cavitation, involving tiny bubbles with instantaneous pressures as high as 75,000 psi and associated temperatures up to 20,000 F, is now used for nuclear decontamination.

(*Continued on page* 230)

Power Lines

Jealous engineers note that moon's gravitational pull on waters of the seven seas continuously dissipates two billion hp in friction. A project designed to halt the waste will use record Bay of Fundy tides to power thirty 10,000-kw generators.

Salad dressing, as well as pulverized coal, chemicals, cinders, can be piped in solid-state, mixed with a little air or water. One coal pipeline in Ohio is 108 mi long.

Live pigs are the latest group to benefit from NDT. Ultrasonic waves are a painless way to test fat distribution on a British bacon boar.

World's longest extension cord is 7.5 mi, handles 25 kv between Washington and the San Juan Islands.

"Reaching the sun," Illuminating Engineers' dramatic progress report, was climaxed by a 10,000 ft-c flood of light from 150 spotlights—a new high for indoor lighting.

EHV transmission will soon be tested by Ontario Hydro, with two 250-mi 600-kv lines. These lines will bring kw from remote hydro sites. But hydro is about used up; Ontario's power future, experts believe, lies in thermal-electric generation.

Vast white coal deposits—hot water and steam—lurk under the Siberian snows, say Russian scientists. While wolves howl overhead, the great artesian pool below perks at 115 F.

Pushbutton control system for Philadelphia's water dept will be nation's first municipally operated load-control center. General Electric plans eight microwave stations to connect center with 92 measurement points.

Sweden's largest water power station will claim several records: three 130,000-kw generators; 178,000-hp Francis turbines; a tailrace tunnel 13,000 ft long, 42,000 sq ft in cross section, blasted out of solid rock.

Drastic control for air pollution was used in England in the 14th century. If you burned sea coal, the authorities smashed your furnace. On the second offense you lost your head.

Awards, scholarships are waiting for engineers and engineers-to-be. Westinghouse Science Talent Search (high-school) is on, and the ASME Woman's Auxiliary has established an annual $750 Marjorie Roy Rothermel Memorial Scholarship to be given to a mechanical engineer for advanced study.

At opening of Nuclear Metals Inc's new plant in Concord, Mass., vice-president Dr A R Kaufmann commented on the probability of tomorrow's highly efficient power reactors using uranium or plutonium fuel. He also discussed best bets for containing these h-t, highly corrosive materials: yttrium for uranium, tantalum or vanadium for plutonium.

A 100-acre man-made cave, the product of 20 years of rock quarrying, has been refrigerated to serve as an underground cold-storage warehouse for 70 million lb of frozen food.

New welding symbols are announced by American Welding Society. Arc-welded spot and seam welds; automatic, machine, manual and semi-automatic welding are covered.

Channel line to join power grids of England and France for peak-load exchange may be in service by winter, 1960. It will stretch for 32 mi.

Boiling-water reactor, 15,000-kw capacity, is to be built by General Electric Company for West Germany's first nuclear power station.

A steam plant for Kittinas County, Washington, has been found feasible by consultants. New 250,000-kw station would be first thermal-electric one built in northwest in 25 yr.

For Calendar of Events turn to page 238

GIANT Turbine Expansion Joints Built by BADGER

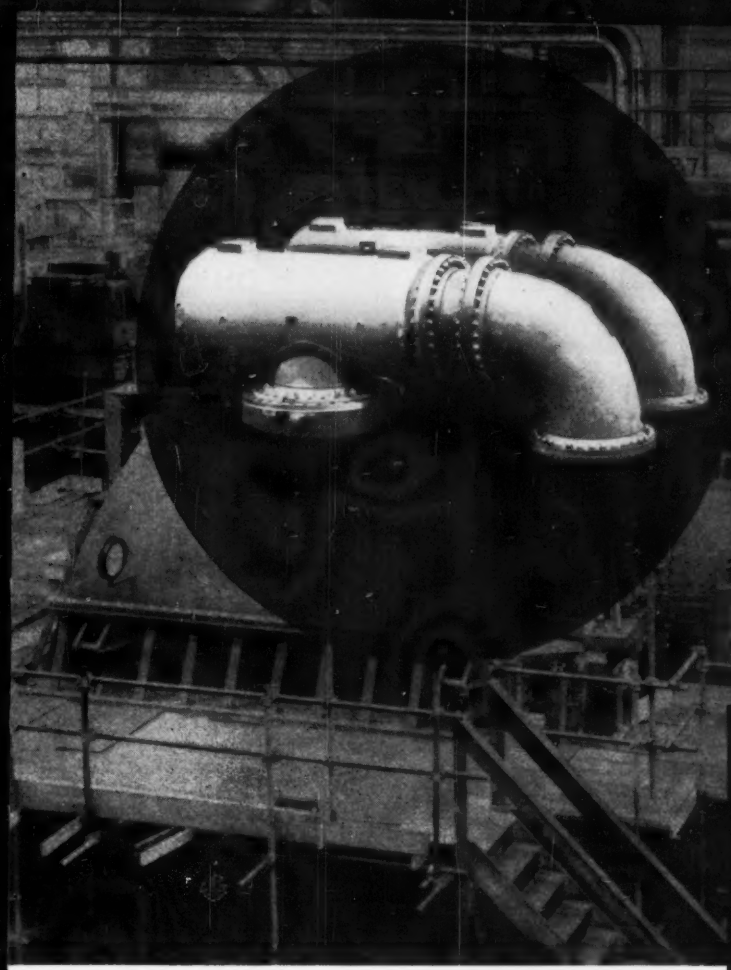
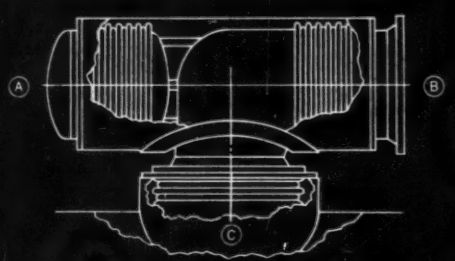


Photo shows 150,000 kw steam turbine-generator unit undergoing tests prior to shipment at General Electric's Turbine-Generator Plant in Schenectady, N. Y. Badger Expansion Assembly is clearly visible atop turbine.

Badger balanced elbow expansion assembly.



Joint A balances thrust due to internal pressure of 65-150 psi; joint B absorbs axial movement; joint C absorbs the differential expansion between the inner and outer casings of the turbine. Assemblies range in size from 36 to 42 inches in diameter.

Custom engineered assemblies include many features of Badger S-R Design

750°F steam is flashed through these turbine crossovers at speeds up to 150 ft/sec and pressures up to 150 psi.

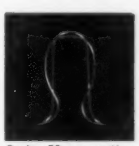
How do you protect piping and turbine casings from the stresses of extreme internal pressure and the expansion such temperature is bound to produce?

Working together, Badger and engineers at General Electric's Large Steam Turbine-Generator Department solved the problem with a new type pressure balanced elbow expansion assembly. Using two separate joints mounted in a T-shape casing (see diagram) the assembly effectively absorbs and controls axial movement. Although the device was custom engineered to General Electric's requirements, the bellows elements are constructed to the Curvilinear Corrugation design recently announced by Badger and now used in all S-R Expansion Joints.

Whether you need standard S-R Expansion Joints or custom equipment, Badger can serve your needs. Get more information — write for illustrated brochure today.

New corrugation and ring designs produce better equalization, "all-curve" flexing

Curvilinear Corrugations used in S-R Expansion Joints were developed by the Badger Research Department. Under operating pressures (white line) the new design produces more uniform movement per corrugation and natural "all-curve" flexing. Stress is reduced... life increased.



Series 50 corrugation cross-section

S-R Joints for higher pressures have tubular Reinforcing Rings. These new rings make metal-to-metal contact only in the "valley" of each corrugation allowing natural "all-curve" flexing (white line). Tubular shape permits greater effective flexing height which contributes to longer life.

Series 150 corrugation and ring cross-section

BADGER

S·R

SERVICE RATED

EXPANSION JOINTS

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Technical briefs

Latest engineering developments for busy power men

13 papers for you on:
ECONOMICS
INSTRUMENTATION
LUBRICATION

World Power Conference highlights economics

EDITOR'S NOTE: *The World Power Conference was recently held in Montreal, Canada. Papers delivered in each of the divisions are described in general reports. These reports summarize the main points of each paper given in that division. In technical briefs coming out of the WPC, some general reports and some individual papers are discussed.*

General report: production and generation—nuclear fuel and nuclear energy

The twelve papers submitted at this session discuss (1) costs of nuclear power (2) production and transportation of the fuel (3) trends in station design and (4) future developments based on research and operational experience.

W B Lewis of Canada estimates costs of slightly more than eight mills per kwhr for pressurized water, dual cycle, and gas-cooled graphite reactors vs six mills per kwhr for heavy-water reactors. These figures apply only to North America. *WPC paper, No. 133B$_3$/2*

J A Jukes and J K Wright, Great Britain, discuss the economics of nuclear fuels in Great Britain. Fuels include natural uranium, thorium, plutonium, U235 and U233. Included in their analysis are reactor and fuel-element design, irradiation level, processing costs, and comments on a balanced program of fuel-producing and fuel-consuming reactors. *WPC paper, No. 120B$_3$/7*

Operational history of Calder Hall, nuclear power plant in England, is reviewed, *WPC paper, No. 48B$_3$/5;* and trends in British nuclear power stations are presented, *WPC paper, No. 88B$_3$/6;* by authors from England. *Division 1, Section B$_3$*

U. S. nuclear power generating costs. *By D H Stewart, United States Atomic Energy Commission*

Economics of nuclear power plants in the U.S. are evaluated in this paper. Primary importance is put on the effect of reactor-system capital costs on final power costs. Author divides components of nuclear-power cost into (a) plant load factor (b) annual fixed charges on plant (c) cost per kwhr of capacity.

Under (a) Stewart points out that the higher the plant load factor, the better is the economic picture, and that nuclear plants should be used as base-load plants in order to get the best cost results. He indicates that favorable comparisons of small nuclear plants with small diesel and oil-fired steam systems need re-examination. Although these small organic-fuel stations have total costs of 20 to 35 mills per kwhr, they also have low load factors (one of the reasons for the high power costs) and failure to consider this makes the small nuclear plant seem better costwise than it actually is.

A fixed charge on investment of 14% for private financing is used, as against 7-9% for public systems both in the U.S. and U.K. It follows that the financing costs will affect fuel selection. Although slightly enriched fuel costs more than natural uranium, this cost is more than offset by smaller equipment for the same output. The present wide difference between estimated and final construction costs will narrow considerably as more experience is gained.

Reduction in capital costs will accrue through (1) larger plants (2) use of standardized equipment (3) performance improvements (4) simpler designs (5) adoption of improved reactor types. Author estimates that a 400-500 mw station will cost about $250 per installed kw, and that due to rising construction costs, a thermal station of this size will cost close to that in the near future. A better understanding of the whole picture will enable designers to get more out of a given design, cut out many of the elaborate safety devices (yet do this safely), and run at higher temperatures for better efficiencies. Water reactors should be the most widely used for the next 10 to 15 years due to the technological lead of this type over others. Net fuel costs will drop from 5.7 to 2.0 mills per kwhr within ten to fifteen years, with the biggest part of this coming from a drop from 3.8 to 0.6 mills in fuel preparation and fabrication. *WPC paper, No. 137B$_3$/11*

General report: thermal energy —system planning

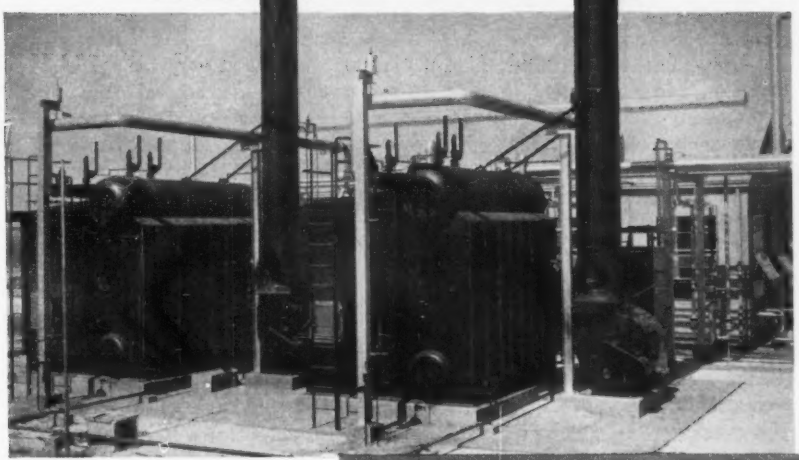
British authors report on efficiencies forced by cost and use of fuel. England was once an exporter of fuel; now is an importer. Therefore getting the most out of what fuel is used is vital. Since the utility system is nationalized, stations are designed for system effect rather than local conditions. Placing stations near the mines rather than near the sea and using cooling towers; making better use of industrial waste heat; extensive electrification of mines; making use of advances in generating design and techniques—these enable the Central Electric Authority to supply 107% more energy than ten years ago with only a 74% increase in fuel consumption, even though fuel is running at a gross calorific value of 10,650 Btu per lb. *WPC papers, No. 69B$_4$/6 and 30B$_4$/5*

Russia, *WPC paper, No. 66B$_4$/10,* is in the same postion. Much designing effort there has been devoted to equipment that can produce energy efficiently using low-grade fuels. Anthracite dust, lignites, peat, and bituminous shales are typical fuels, with moisture contents up to 55% and ash of dry fuel to 60%. They are now working on a cyclone type boiler that will burn anthracite. Russia employs the dual-purpose generating station extensively, supplying both electrical power and steam heat. This has produced electrical energy for about 4500 Btu per kwhr. Poland uses this system in Warsaw, *WPC*

Vogt

Package

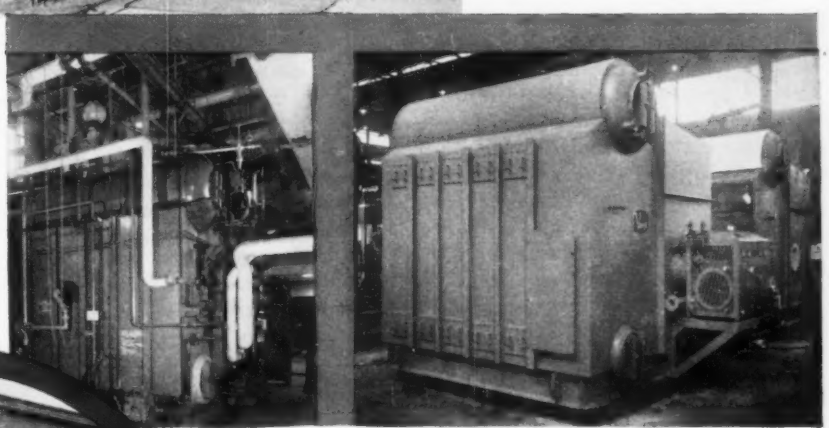
STEAM BOILERS *give* versatility with economy

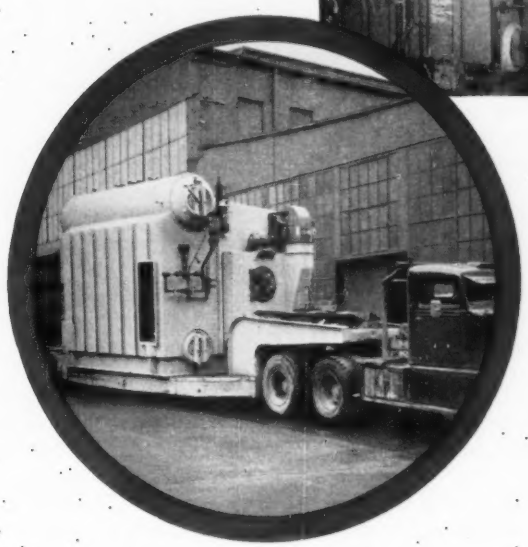


Above: Two units serve a gas pipeline company.

Left: Installation in fibre box-board plant.

Right: Unit for a leading soap manufacturer.





Enroute to an office building.

FOR POWER, PROCESS OR HEATING

Available in capacities from 10,000 to 50,000 pounds steam per hour in three standard pressures of 175, 250 and 375 pounds per square inch gage, factory assembled.

Write for Bulletin PSG-2, 24A-BP

HENRY VOGT MACHINE COMPANY, Louisville, Ky.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis; Charleston, W. Va., Cincinnati.

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DROP FORGED STEEL VALVES, FITTINGS, FLANGES AND UNIONS
PETROLEUM REFINERY AND CHEMICAL PLANT EQUIPMENT
HEAT EXCHANGERS • ICE MAKING & REFRIGERATING EQUIPMENT

paper, No. 13B$_4$/7, getting power for 1134 Kcal per kwhr.

Attention was given to the gas turbine as a prime mover in this session. *WPC paper, No 100B$_4$/1,* analyzes exhaust-heat recovery from a gas turbine in a combined gas-steam cycle. Advantages of steam and gas cycles used in combination over either cycle used singly are discussed, *WPC paper, No. 95B$_4$/2.* Combined cycle is more efficient than either alone, and is so over a greater range of part-load operation. Methods to improve the combined cycle are given. *WPC paper, No. 18B$_4$/3,* lists the advantages of the combined gas-turbine-steam cycle, ways it can be used, and pros and cons of equipment combinations.

Several papers are devoted to gas turbines as peaking units. *WPC paper, No. 17B$_4$/4,* compares free-piston gasifiers and rotating compressors installed in France. *WPC paper, No. 22B$_4$/8,* (Sweden) discusses use of a peaking plant in a combined hydro-steam system. Use of gas turbines to lower transmission costs is also noted. Canadian installations are noted, *WPC paper, No. 116B$_4$/9.* Steam and gas-turbine costs are compared in some unique and easily followed graphical methods. *Division 1, Section B*

Economic trends in the generation of electric energy in the Detroit Edison system. *By G A Porter and R E Hart, Detroit Edison Co*

The authors have two aims in this paper. They (1) discuss economic studies which led to studies in construction, fuel and labor costs and (2) review economic studies related to future development.

Extrapolation of cost figures indicates that by 1983 fuel costs will have gone from 31 to 65 cents per million Btu, construction up from $150 to $510 per kw and labor from $2.84 to $11.40.

They indicate today's economic turbine size for the Detroit system is 340 mw and that 350-mw units are probably the economic limit, since beyond that reduction in installed costs drops off quickly. In general, if the vacuum is better than 1.5 in., hg abs at the turbine-exhaust flange, a cross-compound 1800-rpm turbine using large multiple exhausts gives better economy even with a higher investment than a 3600-rpm unit. And 2400 psi at 1050 F is the economic steam condition, with 1000-F reheat. The thermal gains using higher temperatures don't offset added investment in more costly equipment.

Company surveys of the air-steam cycle used a supercharged boiler, a gas-turbine compressor-generator and a condensing steam turbine. For a binary cycle of 150-mw capacity, about 15% of the total output is generated by the gas turbine.

A thermal improvement of 7.0% is anticipated and represents a major portion of the possible gains for the steam cycle alone over the next 20 years. *WPC paper, No. 62B$_4$/11*

The possibilities offered by artificial cooling for increasing the capacity of electric generators. *By Dr L Heller, Hungary*

One of the principal obstacles to increasing generator capacity is the lack of convenient heat-exchange surface suitable for evacuating increased heat loss without causing design difficulties. Increasing cooling-gas pressure or flow or both can increase the heat-transfer coefficient, but adds design difficulties and increases friction losses.

Therefore the way toward successful cooling of large generators seems to lie in the use of artificial cooling or refrigeration. This has been analyzed and the results are very satisfactory. The increase of generator capacity for a given frame using refrigeration has proved to be economical in all but the most exceptional cases.

The unit selected for examination is a 150-mw generator with maximum cooling-water temperature into the condenser of 86 F, maximum gas temperature of 140 F and conductors at 172 F. A split gas cooler was used so that part of the gas cooling was done by available though warm cooling water and balance by the refrigerant machines. This prevents total cooling by refrigerants and improves the economics. Calculations indicate the optimum ratio of artificial to total cooling is between 25-45%, when cooling water is at its maximum temperature. The example is worked out extensively to indicate the most economical size of equipment added for maximum increase in generator output. Author indicates a refrigerant system worth 10% of the generator will allow a 33% increase in heat loss over the 150-mw ratings.

A steam-jet refrigerating unit was used since operating costs are low and it required no extensive training of power plant personnel. *WPC paper, No. 53B$_5$/3*

Directions for ordering papers on page 206

Instrumentation

RPM indicator for a hermetically sealed (canned motor) pump used in a nuclear power plant. *By D E Collins and G F Skala, General Electric Co*

Pump-speed measurement can be used in the plant protective system of a nuclear plant. If rpm drops too low (through loss of coolant flow) a reactor scram can be activated to prevent plant damage and personnel injury. A speed indicator can also be helpful in providing data needed to verify plant design calculations. Although several ways were tried to get the pump rpm, none was effective. Work was then started on development of an ac tachometer generator.

The generator coil had to fit inside a 5/16 in. thermocouple well. If a magnetized core was used, enough voltage could be induced by nonmagnetized permeable pieces despite the thickness of the well.

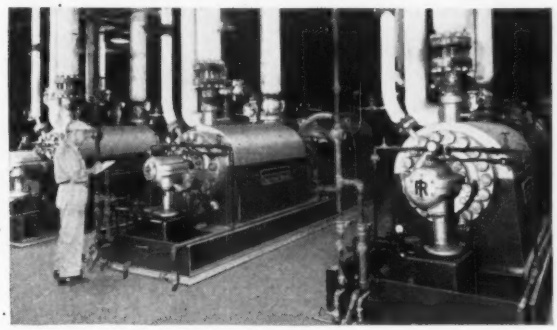
Magnetic end pieces are pressed on a 0.187 in. dia Teflon-coated Alnico-V core which is then magnetized and wound with 4000 turns of Teflon-insulated wire. Final core size is 0.297 OD by 1⅛ in. long. Coil well is 304 stainless steel.

Rotor, also of 304 stainless attached to the pump shaft, contains six poles 1¼ by ¼ in. thick of 410 magnetic stainless. Final clearance between rotor and coil well is 0.030 in. (*Continued on page* 198)

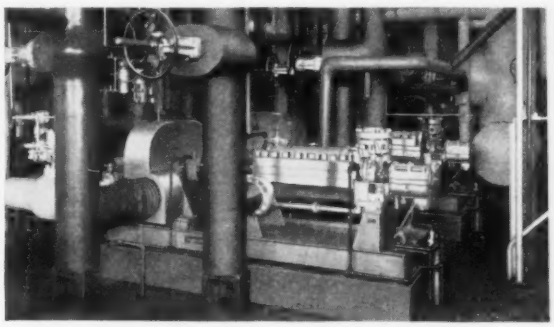
BOILER FEED PUMPS GIVE DEPENDABLE PERFORMANCE

at all pressures, capacities, temperatures.

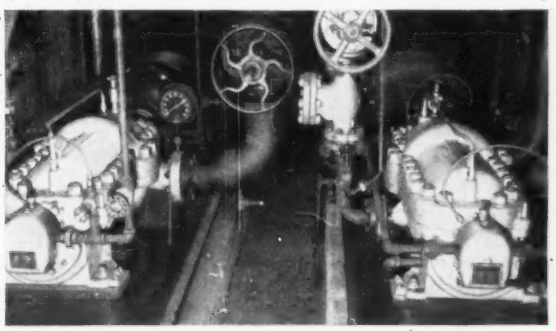
Typical I-R installations indicate wide range of use in central stations and industrial plants



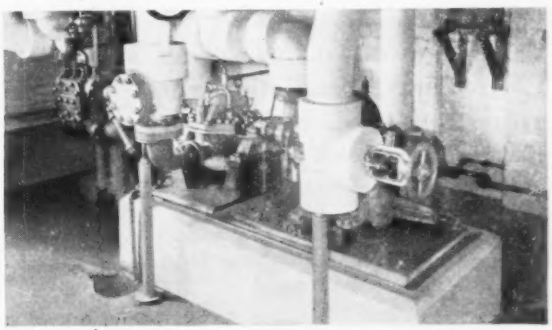
PRESSURES UP TO 6500 psi.—Class CHTA-CHTB: These multi-stage, cylindrical "double-case" pumps meet the most exacting needs of the highest-pressure boilers in modern central station service. Each of the above pumps handle 1100 gpm of feedwater at 2395 psi.



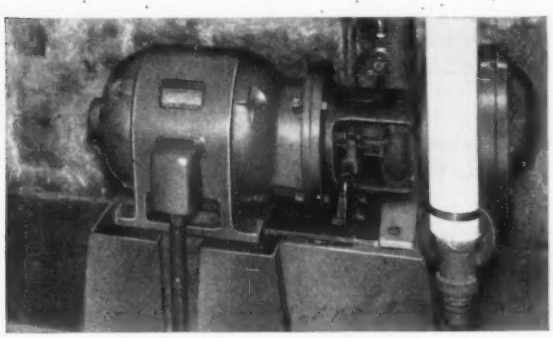
PRESSURES UP TO 1200 psi.—Class HMTA-HMTB: A complete line of multi-stage centrifugal pumps featuring a symmetrical, horizontally-split casing, and a simplified unit-type rotor assembly. The pumps illustrated are on boiler feed service in a large textile mill.



MEDIUM PRESSURES UP TO 1000 psi.—Class CNTA: Symmetrical design with unit-type rotor gives CNTA pumps higher efficiency, easier maintenance, and attractive modern appearance. Installed in a large paper mill, the boiler feed pumps shown operate at 3560 rpm and deliver 180 gpm at 605 psi.



PRESSURES TO 450 psi.—Class GT: Dependability is designed into this line of two-stage, horizontally split pumps. Standard construction includes renewable wearing rings and water-cooled, ring-oiled bearings. Pump shown serves as a boiler feed unit in a large candy factory.



PRESSURES TO 250 psi. — Motorpumps: A complete line of space-saving centrifugal pumps, including both close-coupled and cradle-mounted types. Single, two-stage, and vertical four-stage models are available. Pump shown is handling boiler feed in a leather factory.

Ingersoll-Rand boiler feed pumps have many refinements in design and construction that add up to high operating efficiency. Skilled manufacture and painstaking factory inspections assure dependability built into every pump. Inherent simplicity and ruggedness mean easier and less maintenance—and trouble-free performance.

Whatever pressure or capacity you need, Ingersoll-Rand can supply a boiler feed pump for the job. I-R engineers will gladly help you select the pump that meets your needs.

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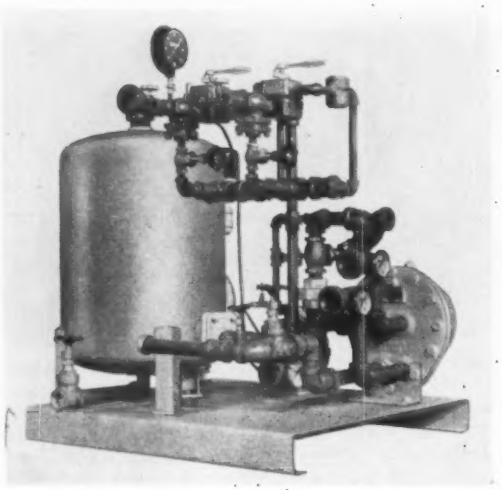


Basic blowdown, sampling system trims installation costs

1201 • Low-cost pre-engineered blowdown and sampling system provides full functions of continuous blowdown, but under manual control. Unlike the console system (see POWER, Sept 1958, p 140), this basic unit does not include a cabinet or sampling sink, and it has less instrumentation. It's priced at $2200 to $2800 . . . about half the cost of the console model.

Offered as a packaged unit, components include: (1) volume control valve (2) strainers with drain manifold (3) insulated flash tank with drainer, high-level alarm and safety valve (4) sample cooler (5) main heat exchanger and (6) sight flow indicators. Manual instead of automatic control is provided for pressure flush, aftercooling and sample cooling.

The pre-enginered system is supplied ready-to-install, with all interconnecting piping in place. Yet, it offers the inherent advantages of efficiency and heat recovery common to continuous blowdown systems. Maker also reports that the system requires less space than conventional "assembled" systems and eliminates "spaghetti" piping arrangements. Thus total cost is considerably lower.

Basic systems accommodate two, three or four volume control valve "stations" (corresponding with the number of boilers involved) for either 250 or 600 psi, with capacities to 6000 lb per hr of total blowdown.—*Fred H Schaub Engineering Co, 2110 S Marshall Boulevard, Chicago 23, Ill.*

Boiler return system ups efficiency

1202 • Better performance with lower operation and maintenance costs are reported for improved differential drainage and boiler return system. System meets need wherever steam is used for processing at 30 psi or more.

New features claimed are a 2-stage pump to replace dual-pump setup formerly used, floatless liquid-level control, chrome-plated pump internals, and Teflon packing in the differential valve.

System is reported to return condensate from steam processing units to boiler at 300 F or higher—only 15 to 20 F less than the temperature at operating pressure. This lowers fuel costs 10 to 25% over the usual open system. Raw makeup water needs are trimmed to 90%, thereby minimizing corrosion and boiler strain.—*Stickle Steam Specialties Co, 2215 Valley Ave, Indianapolis 18, Ind.*

Packaged boilers go "king size"

1203 • New line of natural-circulation packaged boilers features the first units of their kind capable of generating steam at capacities to 100,000 lb per hr. They're especially adaptable to operation in the electric utility industry and, according to company officials, are expected to cost about 20% less than units of similar capacities which must be erected in the field. Lower cost is made possible through use of time-proven natural circulation; no recirculating pumps are needed, simplifying operating, maintenance problems.

Units operate at steam pressures of 250 to 775 psi. Wide furnaces allow adequate burner clearance, contributing to complete combustion throughout the range of capacities. Design allows boilers to burn either oil or gas or a combination of the two fuels. Notable feature is the drainable superheater which is cooled and protected with steam as soon as drum pressure is raised. Ease of draining the superheater permits a fast safe startup, makes quick boiler storage possible.—*The Babcock & Wilcox Company, 161 E 42nd St, New York, N.Y.*

Controller programs burner operations

1204 • Plug-in subassembly units contain all equipment needed to program any standard flame-failure control. Face plate on flush-mounted timer shows its position at all times, and circuit design eliminates as many components as possible. Field replacement requires less than one minute.—*Compact Controls Co, Inc, 1633 N Halsted St, Chicago, Ill.*

For more data on these items, use the handy post cards on page 165. Identify your request with item number.

CRANE Pressure-Seal Bonnet Valves

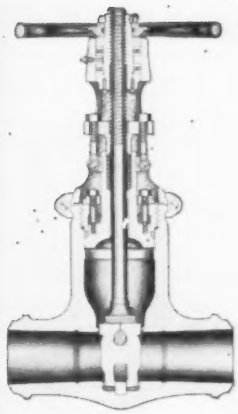
In gate, globe, angle and stop-check patterns—flanged, butt- and socket-welding ends—rated in accordance with A.S.A. in 600-, 900-, 1500- and 2500-pound classes. Sizes: gates—1 to 24 inches; globes and angles—1 to 16 inches; checks—2½ to 12 inches; stop-checks—6 to 12 inches

Crane design is at its very best in this streamlined line of pressure-seal bonnet valves—made expressly for high-pressure/high-temperature service in central stations and industrial power plants.

Bonnet joints in these valves are sealed by a unique method which uses *internal fluid pressure* to effect a leakproof seal. This method virtually eliminates bonnet-joint maintenance—and maintenance costs.

Other features include: weight-saving body design—saving up to 60% over conventional design—swivel action yoke and clamp which permits choice of position for motor or gear mechanism . . . one-piece sealing ring . . . Stellited seating surfaces.

Write to address below for descriptive Circular 1936.



CRANE *high-pressure/temperature valves assure leakproof service—less maintenance*

CRANE Lip-Seal Bonnet Valves

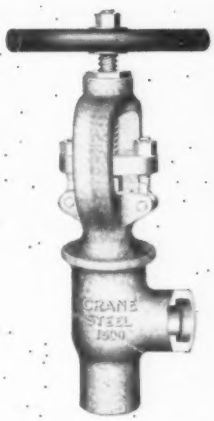
In globe, angle and lift-check patterns; sizes—½ to 2 inches; screwed and socket-welding ends; rated in accordance with A.S.A. in 1500- and 2500-pound pressure classes

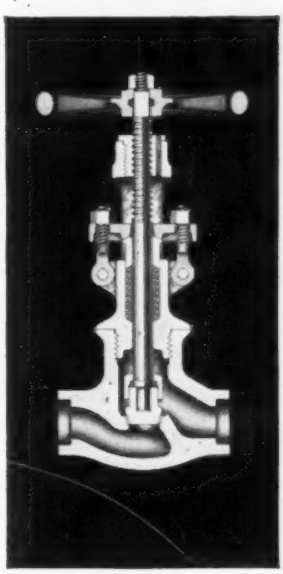
These popular Crane valves are widely used on steam, boiler feed, drips, drains, by-pass, blowdown and similar piping services.

They assure you absolute tightness, no bonnet-joint maintenance, minimum valve weight and bulk without sacrificing strength—and easy, fast dismantling and reassembly.

Features include: lip-seal design which permits re-welding without damage to the valve . . . improved disc-stem connection that minimizes vibration . . . two-piece, non-binding ball-type gland construction . . . and Stellite seating surfaces.

For details, write to Crane Co., for Circular 2099.





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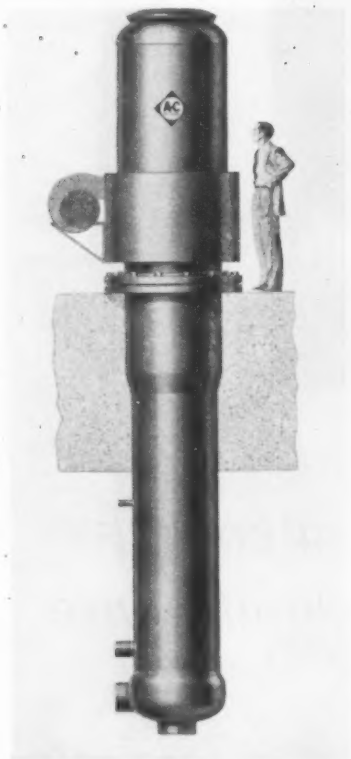
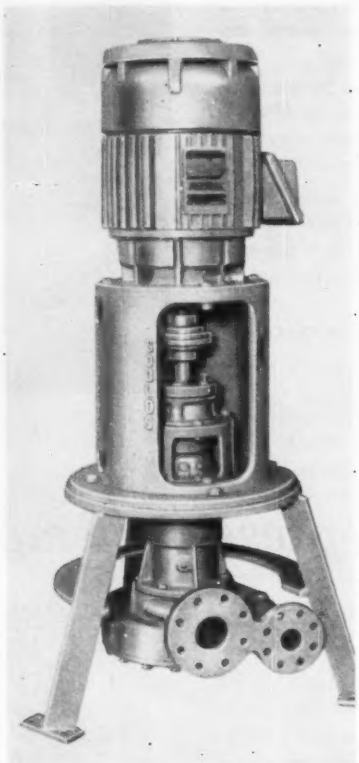


Nuclear-reactor motor-pump has sealed magnetic clutch

1205 • Ordered as a test prototype for the 75-mw sodium-graphite Hallam Power Facility, this unit is rated 300 hp, 7200 gpm at a 150-ft head of 1000 F sodium. Design combines a standard centrifugal pump and tube type motor, with the motor modified to secure a gastight enclosure.

Hermetic sealing is said to eliminate mechanical seals and offer maximum dependability and efficiency. Motor's gastight jacket permits an inert gas to transfer heat to air directed into the tubes surrounding the stator, by a fan mounted external to the motor.

Pump speed can be varied from 1100 rpm to 110 rpm through a hermetically sealed magnetic clutch, to control flow to reactor and through primary heat-exchanger loop. This eliminates control valves, maker states. — *Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis.*

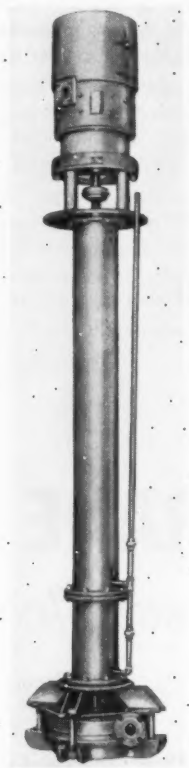


Process pumps have glass, stainless steel liquid ends

1206 • Tripod-mounted vertical centrifugal units come with liquid ends of stainless steel or other corrosion-resistant metal, or glassed.

Metal-end pumps are designed for handling highly volatile, inflammable, toxic or explosive liquids, where pumpage must be isolated from atmosphere. They can also pump liquids at low or high (–320 to +550 F) temperatures, and are designed with a closed adapter and column, so that pressurized inert gas or clear compatible liquid can be introduced.

Glassed-end pumps are for use where liquid handled is corrosive or where metal contamination must be prevented. Metal-end pumps are available in nine sizes from ¾- to 3-in. discharge, capacities to 800 gpm, heads to 300 ft. Glassed-end units come in capacities to 700 gpm, heads up to 140 ft.—*Goulds Pumps, Inc, 49 Black Brook Rd, Seneca Falls, N. Y.*



Heavy-duty slurry pump is for wet-pit sump service

1207 • Designed for submerged operation in wet-pit sump service, unit can handle heaviest slurries of sand, coal, tailings, crystals, chemical sludges or abrasive plant drainage, according to manufacturer.

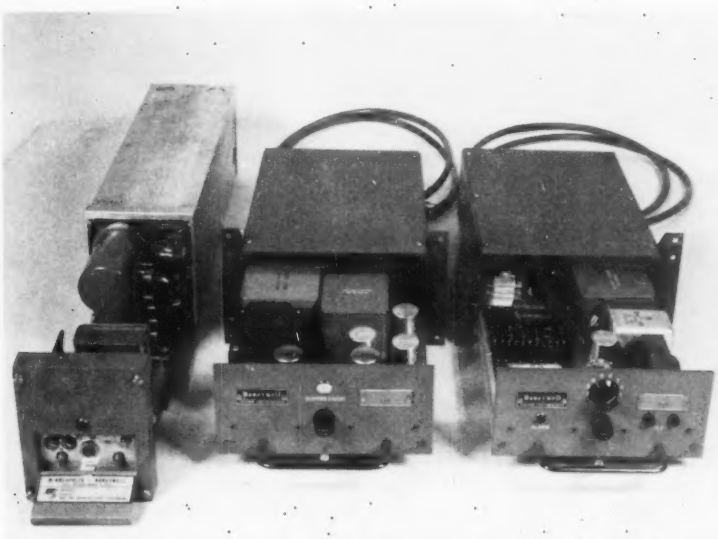
Designated type *RXV*, the pump comes in nine models. Low speed and continuous duty with both heavy and fine slurries is a feature. The unit can be quickly dismantled, since there are only four bolts clamping pump's liquid end. Bearings are water-lubricated.

There is no stuffing box or vapor binder, maker states. Unit has self-contained thrust carried in the motor base. All wearing parts are interchangeable with parts of the *RX*, horizontal model.—*Morris Machine Works, Baldwinsville, N. Y.*

For more details on these items, use post cards, p 165. Identify your request with item number.

Begins on page 152

Transmit data over any channel with this telemetering system



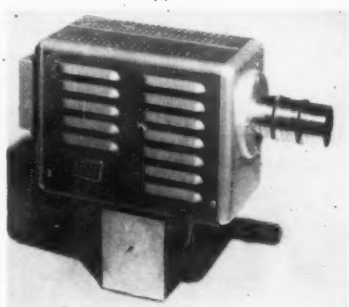
1208 • Long-distance transmission of industrial process data is possible with miniaturized, transistorized frequency type telemetering system. Variables such as temperature, pressure, liquid level, flow, megawatts, are transmitted in the form of electrical signals.

The system is made up of a millivolt-to-current transmitter, left; a current-to-frequency transducer, center; and a frequency-to-current transducer, right. For current, voltage or mw measurements, a thermal converter is used with MV/I transmitter.

Any communications channel can be used, and frequency bands are 5 to 15 cps or 10 to 30 cps.—*Minneapolis-Honeywell Regulator Company, Wayne & Windrim Ave, Philadelphia 44, Pa.*

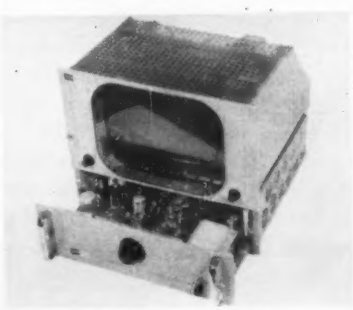
Self-contained TV camera is completely automatic

1209 • Model 63A automatically accommodates a light range of 120 to 1, with 50% change in video output level—equivalent to automatic adjustment of lens stops from f/1.5 to f/16. It can self-adjust beam, target and electrical focus circuits to optimum values. Unit comes in a blue-grey hammertone case. It weighs only ten lb.—*Thompson Products, Inc, Dage Television Div, Michigan City, Ind.*



Closed-circuit TV monitor has polarized filter

1210 • Built-in fully automatic light adjustment on camera, monitor with 14-in. aluminized picture tube are features of closed-circuit TV system. Camera will instantly adjust to variations in light level up to 1000/1. Monitor has a polaroid filter, a second anode voltage of 16,000 v. Geometric distortion is never more than 2%, maker states.—*Cohu Electronics, Inc, Kin Tel Div, 5725 Kearny Villa Rd, Box 623, San Diego 12, Calif.*



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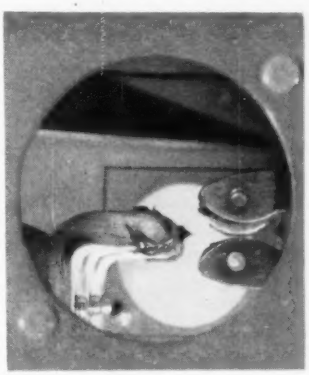


Visible-contact breaker . . . p 188

. . . or other product news appearing on following pages

Reserve-power switch . . . p 186
Prefab piping system . . . p 188
Boiler-tube sheath . . . p 190
Vertical turbine . . . p 190
H-p needle valve . . . p 192
Boiler-water analyzer . . . p 194
H-t cable jacket . . . p 196
Explosionproof relay . . . p 196

George Edwards

asks: "Are you running 'Full ahead' or anchored?"

There's a romance connected with steam engines which never fails to grip the heart and imagination of both young and old. I'm told that it was a thrilling sight to see the horse-drawn steam fire engine go clanging down the street with its comet's tail of sparks flying from the boiler's stack. When more modern equipment took over, something was lost forever from the sight and sounds of a fire alarm.

"Steamboat 'round the bend" is a cry heard only in the movies these days. And with the passing of the steam locomotive, there's little left to tie us to the day of the steam engine as we knew it.

Some engineers, unwilling to let the ties break completely, find ways to keep the steam engine in their lives. Pictured, above, is the way my friend Capt L S McCready, of the U.S. Merchant Marine Academy at Kings Point, N.Y., does it. Mac took a 26-ft Navy motor whale boat and installed a complete steam plant. He has logged several thousand miles in his boat and wouldn't swap places with the *Queen Mary's* skipper.

For others who'd love to have something like this, but haven't the time to do the job, Fred Semple can step into the breach. He built a little steam-powered job for himself a few years ago and found that a lot of people wanted one like it. Now, from his plant in St. Louis, Fred can provide the works from boiler to propeller. All you have to do is supply the boat.

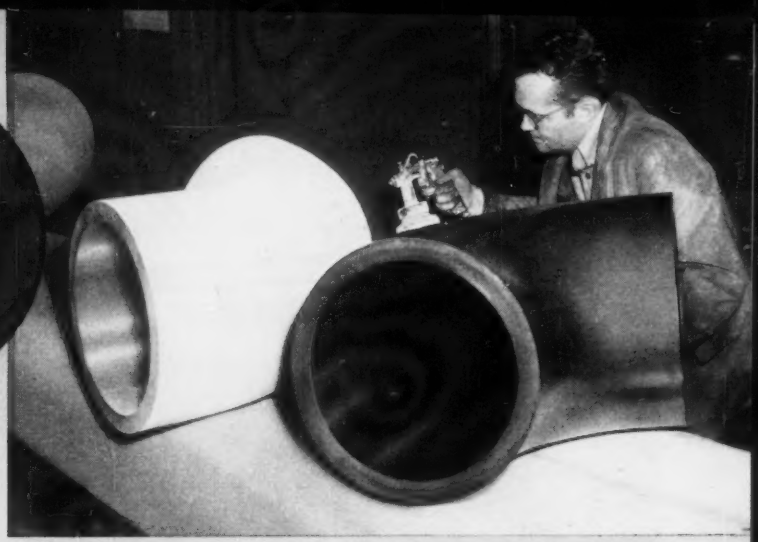
A great many boat people probably wonder why in the world a guy would want to power a small pleasure boat with steam. And you could spend a year telling them and they still wouldn't understand. But to all the Mac's and Fred's, it's like reliving part of their lives. They know that the steam engine can't compete with today's steam turbine and internal-combustion engine drives in industry, but there's no reason why they can't keep it alive as a hobby. And they thoroughly enjoy it as just that.

On the other hand, there are guys who are living with steam engines, but for a different reason. These are the people who are keeping obsolete engines in service, often driving just-as-obsolete equipment. Why they're operating this way isn't too clear to me. By getting rid of these museum pieces they'd do a lot to up plant production and get rid of maintenance millstones hanging around their necks. Savings would go a long way toward paying off the cost of modern drives.

Being "steam-engine minded" can be a real source of leisure-hour pleasure, as it is to Mac and Fred and hundreds of kindred spirits. But it has no significant place in today's power plant, particularly in the face of the big swing toward plant modernization and expansion.

The *PLAN '59* message that all McGraw-Hill magazines have featured during the past months points up how sharp-thinking people in industry are gearing for bigger output than ever before. Conversely, I think it should remind "steam-engine age" management that they aren't going to be able to send a boy to do a man's job.

SPECIAL FITTINGS Need *NOT* Delay You



Entire interior and exterior surfaces of special stainless elbows for nuclear power plant are inspected with dye penetrant in search of microscopic surface imperfections. Elbows are 16" O.D. with 102° included angle and long tangent on one end.

Midwest Can Make *and* Deliver

An exclusive and flexible manufacturing process enables us to make welding fittings of any material available in plate that can be worked and welded. As plate is more readily available than pipe, in special materials and thicknesses, deliveries are much better.

Elbows with special included angles, special tangents, special wall thicknesses and of special materials are easily and promptly made. Closer tolerances are inherent in the Midwest process. Quality control always exceeds code requirements . . . can be as comprehensive as you need.

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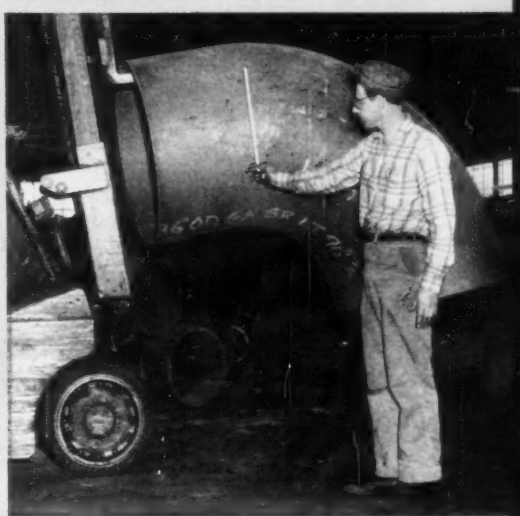
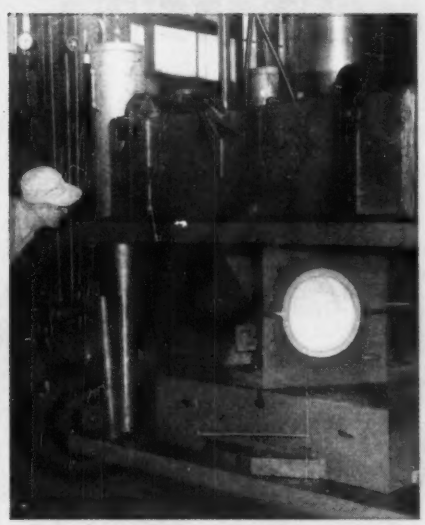
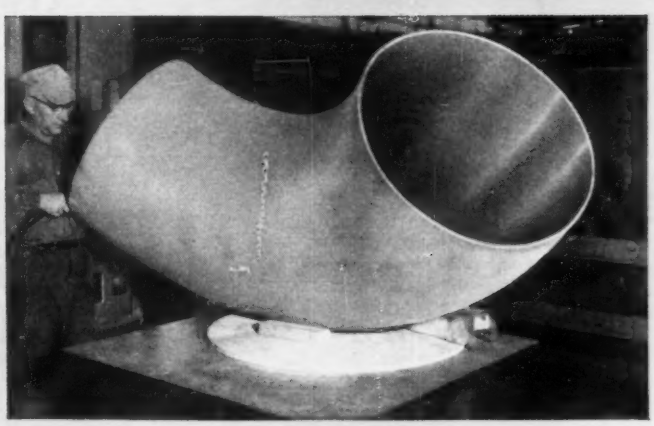


Note the exceptionally long tangent on one end of this 36" O.D. 90° short radius elbow made of special carbon steel. Similar tangent could have been provided on other end if required.



18" O.D. x 1¼" wall 90° elbows (2¼% chrome ½% moly) being sized in compression by totally enclosing dies. The exceptional dimensional accuracy that results is possible only with the Midwest process.

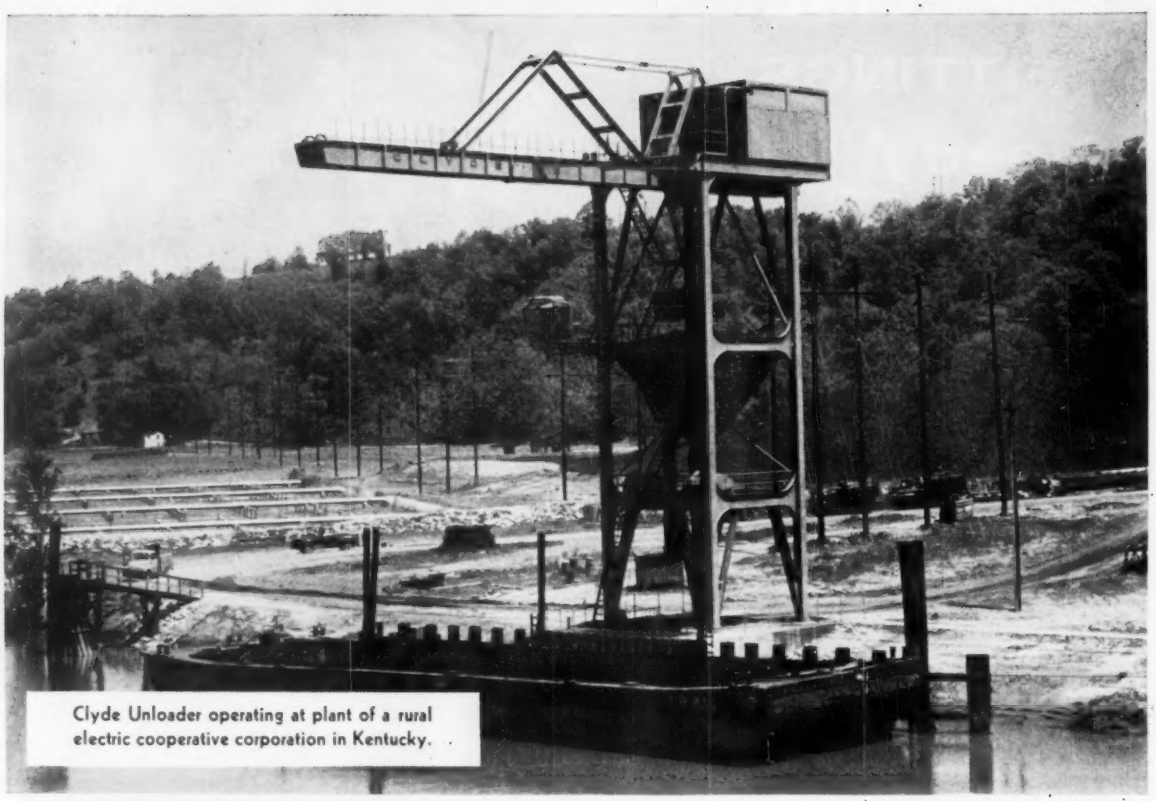


Interior surface of 30" O.D. stainless steel welding elbow for liquid sodium nuclear system required a finish of 125 micro-inches or better.

8060

MIDWEST WELDING FITTINGS

IMPROVE PIPING DESIGN and REDUCE COSTS

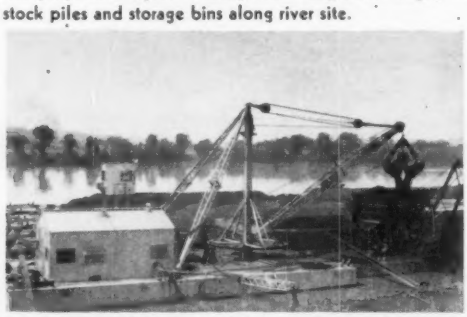


Clyde Unloader operating at plant of a rural electric cooperative corporation in Kentucky.

Coal handling is simple as 1, 2, 3, with . . .

Three specialized Clyde units offer lowest cost coal handling

Self-propelled Clyde Whirley unloading from barges to stock piles and storage bins along river site.



Barge mounted Clyde hoist and derrick handling coal from barges to conveyor hopper for distribution to cars and trucks.

1 CLYDE UNLOADERS

Clyde Unloaders . . . the finest, most modern machines for high speed handling of bulk materials from barges or ships direct to distribution hopper in tower. Unloader can be equipped with self-propelling trucks or be stationary mounted. Three standard sizes with free digging capacities up to 1200 tons per hour.

2 CLYDE WHIRLEYS

Clyde Whirleys are specially designed for efficient, economical and fast cycle rehandling of materials. Their long reaching, full-revolving booms permit servicing exceptionally large areas. Materials can be unloaded from barge or ship to stock piles, storage bins or loaded directly into cars, trucks or hoppers.

3 CLYDE DERRICKS

Clyde Stiff Leg Derricks powered by Clyde hoists make an ideal combination for low cost, heavy duty material where degree of swing is limited. Anti-friction bearings on Clyde hoists and derricks reduce friction losses, save maintenance costs and permit heavier pay loads to be handled with less power consumption.

"Quality is Always Foremost in Clyde Products. Write for Detailed Bulletins on Any Item."

CLYDE RIC

CLYDE IRON WORKS, Inc.

Established 1899

DULUTH 1, MINNESOTA

HOISTS : DERRICKS : WHIRLEYS : UNLOADERS
BUILDERS TOWERS : CAR PULLERS : ROLLERS

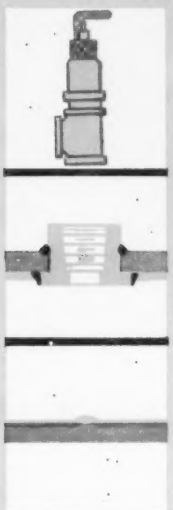
there is no equal

When you Specify

P-K COPPER-LINED STORAGE WATER HEATERS

P-K's exclusive design features assure trouble-free service and rust-free hot water.

Here are four reasons why...

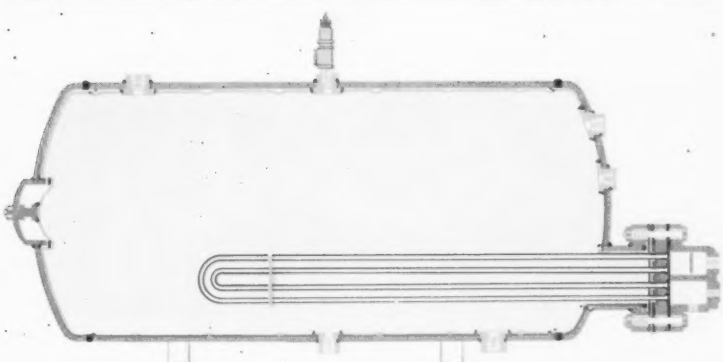


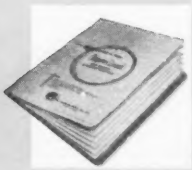
1 P-K Vaco-Valve®
assures absolute protection. Not an ordinary check valve, but a precision-made vacuum breaker designed by P-K.

2 Couplings and Fixtures
are of copper-silicon. Couplings are heavy reinforced forgings, welded to both sides of shell and to lining.

3 Expansion Joints,
placed every 12″ throughout shell, permit longitudinal expansion of lining.

4 Steel Shell
is double butt welded and all inside welds are ground flush. Stored hot water contacts **no** metal other than copper or copper-silicon.





Data File
on P-K copper-lined heaters, including sample specification outline and detailed construction features, is yours for the asking.

Patterson Kelley
Water Heater Division

storage water heaters • instantaneous heaters • convertors • fuel oil heaters • water to water exchangers

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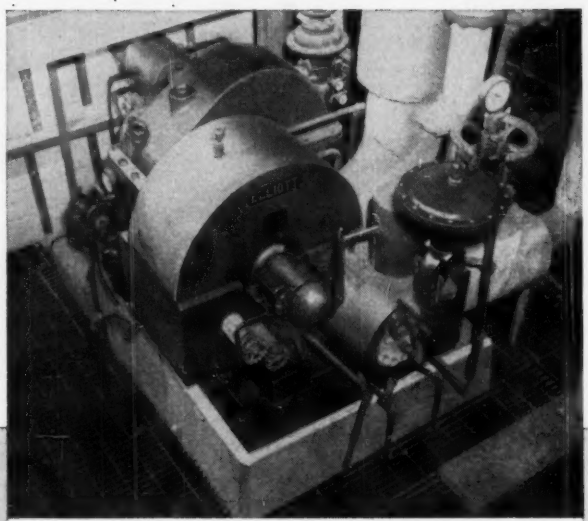
since nineteen hundred four
MOTORS
since eighteen hundred eighty eight

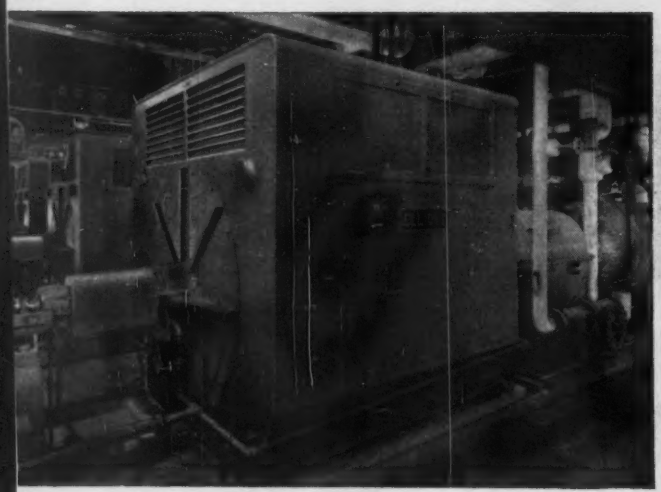
for your auxiliary drives...

Steam or Electric
Large or Small
Indoor or Outdoor

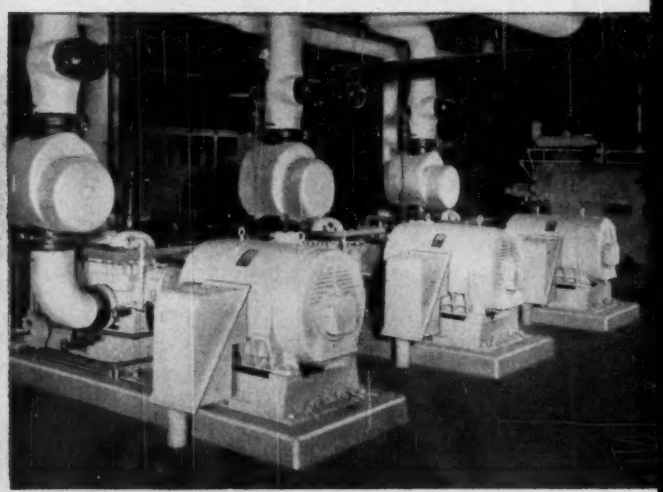


This Elliott geared turbine drives the induced-draft fan serving the 120,000-lb-per-hr boiler for a northeastern pulp mill. Elliott turbines are noted for simplicity, flexibility and year-in and year-out dependability.

ELLIOTT Company
JEANNETTE, PENNSYLVANIA

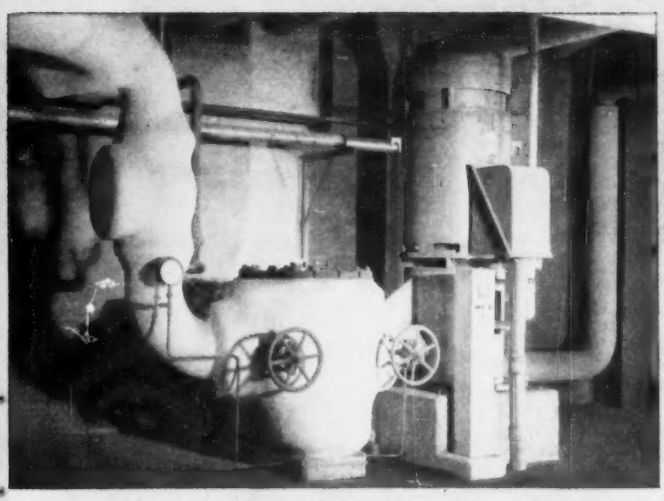


Biggest boiler-feed pump motors in the country—each rated 5000 hp at 3600 rpm. Quick-access openings visible on near end of motor; removable swing-down filter panels on each side. Elliott "Super-Quiet" enclosures. 6000-hp Elliott motors will soon be operating.

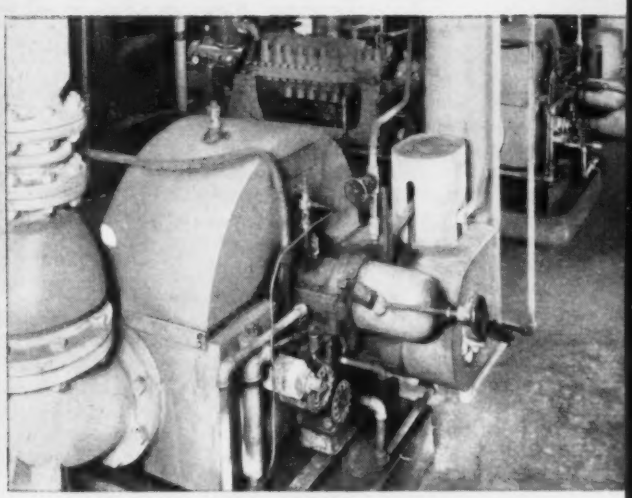


Heater drain pumps are driven by identical 200-hp, 3600-rpm Elliott motors. Elliott water strainers are mounted in pump inlets. Other Elliott products for power plants include condensers, ejectors, deaerating heaters, tube cleaners and expanders.

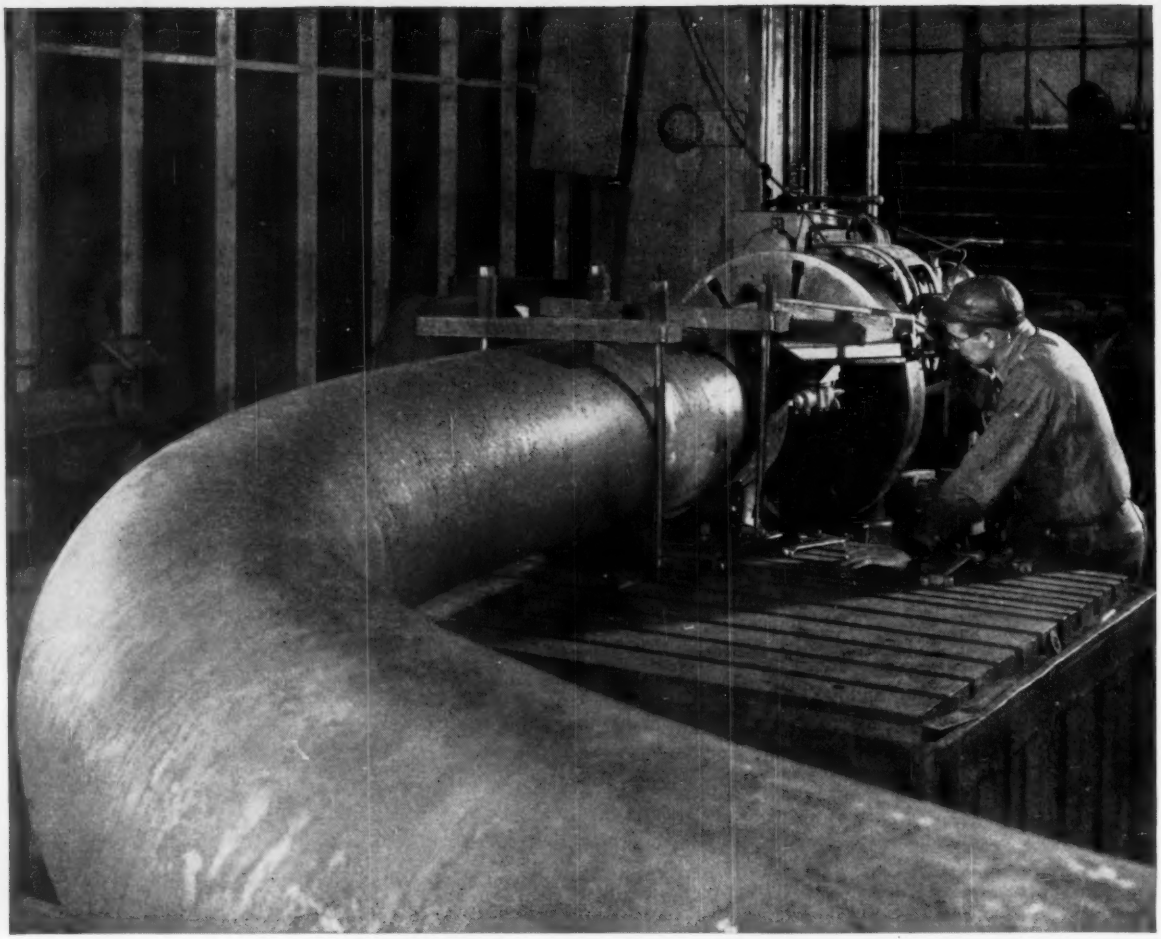
Dripproof 600-hp, 900-rpm Elliott motors driving line of coal pulverizers. Elliott FABRI-STEEL construction assures structural rigidity; FABRI-SEAL insulation assures maximum service life.



Here an Elliott 250-hp vertical, dripproof motor is shown driving a condensate pump. An Elliott twin basket water strainer which protects the pump can be seen at the left. Elliott C-W motor experience dates from 1888.



250-hp, 3550-rpm Elliott turbines drive boiler feeders in this industrial plant. All major auxiliaries in this station are Elliott turbine-driven. For over a half century, Elliott has been building turbines and turbine-generators.



Boring mill cutting bevel on 18" diameter pipe with 3¼" wall in preparation for welding.

QUALITY CONTROL— key to superior performance

Dravo's Pipe Fabrication shops at Marietta, Ohio, are staffed by highly skilled men who have at their command the very latest in fabricating equipment, including a variety of devices for Quality Control checks. However, at Dravo, Quality Control goes beyond routine checks for compliance with applicable codes. Every step in the fabrication of piping is performed in accordance with procedures developed during Dravo's many years of experience, and is subject to rigid inspection.

Here are some of the Quality Control checks which assure dependable performance in Dravo piping.

1. Radiographic examination of weld. Heavy walled piping may be subjected to several such checks during welding.
2. Heat treatment for stress relieving or normalizing under controlled furnace conditions.
3. Careful preparation of weld area. Dye-penetrant test may be used to assure sound metal at the weld area.
4. Dye-penetrant or magnaflux inspection where indicated.

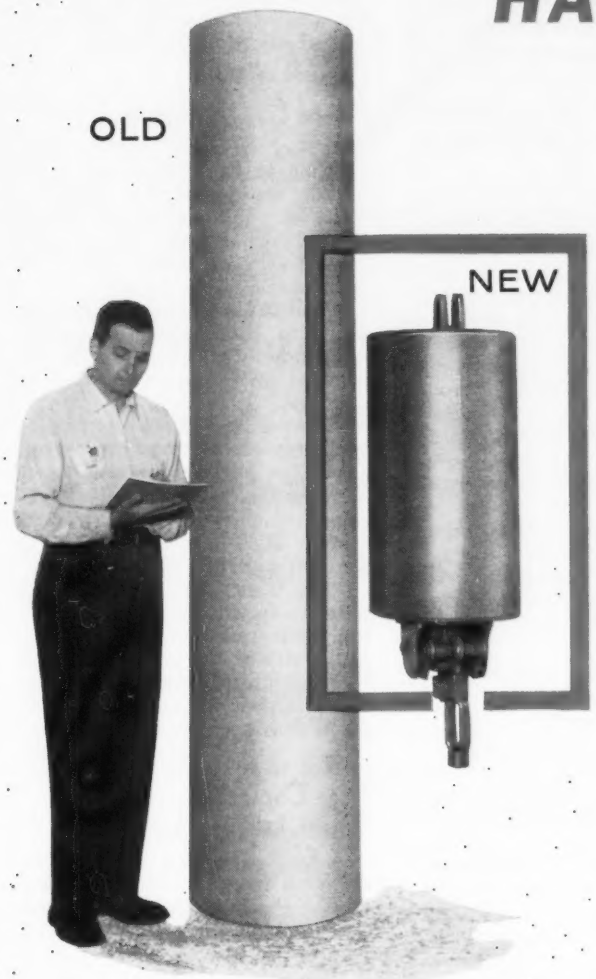
Dravo has the facilities for the fabrication of all kinds of piping. But whether routine or out of the ordinary, every job is held to Dravo standards. A Dravo Piping engineer will be glad to work with you on your next piping job. Write Dravo Corporation, Pittsburgh 22, Pennsylvania.

DRAVO
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

DESIGNED FOR THE ATOMIC AGE...

New BERGEN "DS" Disk Spring HANGERS!



Now from the research laboratories of Bergen Pipesupport Corporation comes a *new concept* in spring hangers designed to meet the changing requirements of atomic and conventional power plants. This new concept, the BERGEN "DS" Disk Spring Hanger features:

- *Space Reduction*—new designs save up to 75% of the space required by helical spring design.
- *Lighter Weight*—reduces weight of supporting steel members and makes installation easier.
- *Greater Load Carrying Capacity*—disk spring device readily applicable to support of extremely heavy loads far beyond the range of conventional spring hangers.

The unique new BERGEN "DS" Hanger employs Belleville-type disk springs for a totally new design of variable and constant support spring devices for the flexible support of piping and equipment. In these new hangers, springs of like characteristics are employed in both types. The variability and load-deflection characteristics are directly related to the number of disks that are used. Actually, the only difference is the number of disk springs used for the required degree of variability.

BERGEN "DS" Hangers are particularly recommended for... large loads with low or medium travel... where space must be conserved. Special attachments are available for all units to facilitate field erection.

All the outstanding features of BERGEN Coil Spring Hangers such as factory calibration and testing, pre-setting to cold position, hot and cold position buttons, travel stops, field adjustment, and permanent lubrication have been incorporated in the new "DS" units.

Whether you are supporting piping, or equipment for atomic or conventional power plants, why not look into the new BERGEN "DS" Hangers. Write today for complete information.

BERGEN PIPESUPPORT CORPORATION
50 Church Street, New York 7, New York

Hall Industrial Water Report

VOLUME 6 DECEMBER 1958 NUMBER 6

From Kerosene to 100 Octane

The cat crackers of today's oil refineries bear little resemblance to the batch stills of yesteryear. But the old and the new do have one thing in common—water problems. Treatment of water for boilers has become more critical because of higher pressures and ratings and greater necessity for avoiding interruptions in production. The same is true of service and cooling water treatment. And waste water problems are becoming more acute because of the pressure to conserve water and clean up our lakes and rivers.

Hall Laboratories engineers have been working with water in refineries as well as in other industries for more than thirty years. They are ready to help you with all your water problems.

Sweetening Sour Water

Deposits formed so rapidly in the sour water deodorizing tower at a Canadian oil refinery that chemical cleaning was required every month. Each cleaning job cost $600.

When he learned of the problem, Hall engineer J. S. Sullivan recommended the use of Calgon and Hagan Dispersive. The cost of these chemicals would be only a fraction of the cost of chemical cleaning.

After treatment was started the tower operated without any indication of deposit formation and inspection was postponed for three months. When the tower was inspected, Sullivan and the operating men were gratified to find it clean.

Failure in Sixteen Days

A Northwestern oil refinery installed two boilers, and a hot process lime-soda softener to treat the hard, high solids feedwater. Operation was started without phosphate conditioning of the boiler water and sixteen days later one boiler was out of service with ruptured tubes as a result of scale formation.

In response to the call for help a Hall engineer left for the plant immediately. He found that plant operation depended upon keeping the remaining boiler in service. This seemed doubtful because a peek into the furnace revealed overheated spots on many tubes, a literal red light warning of insulating scale within them.

There was no time to start with a low phosphate feed and to gradually build it up so as to avoid rapid loosening of scale and possible tube blockage. Full phosphate conditioning was started at once. Then the Hall engineer had to sweat it out. Would there be tube trouble? Would carryover occur because of high concentrations? Fortunately, neither occurred. Within 24 hours the overheated spots disappeared and everyone relaxed.

Without proper conditioning of the boiler water, tubes failed in sixteen days. Following the establishment of desirable conditions many years passed without further difficulty.

Saving by Wasting

A petrochemical plant used well water for cooling in once-through services which required colder water than the cooling tower could deliver. Practically all of the well water was then discharged to the cooling tower system as make-up. Since this was far more water than was actually required for make-up, the amount of blowdown from the recirculating cooling system was about four times what it should have been.

Treatment of the recirculating cooling water for corrosion control involved the use of sulphuric acid, Calgon® and Coraid.® Hall engineer S. R. Osborne pointed out that the excessive blowdown was resulting in the wastage of large amounts of chemicals—more than $60.00 worth a day. He recommended that this be saved by discharging to the sewer all of the well water not actually required for make-up to the recirculating cooling system.

In most plants Hall engineers are looking for ways to save money by reusing or recovering cooling and waste water. In this case the plant could save about $22,000 annually by wasting rather than recovering once-through cooling water.

Pitted Gauge Glasses

A very common problem often puzzling to boiler operators is the internal wastage of glass above the water level in gauge glasses. Water level visibility is impaired and sometimes the glasses are weakened to the point of failure.

When this problem was first referred to Hall Laboratories years ago, study by the Hall research staff revealed an interesting process of corrosion.

Steam is continually condensing on gauge glasses above the water level. The hot, pure water slowly dissolves the glass. Sometimes dissolved silica reprecipitates as an opaque deposit which imparts a frosted appearance to the glass.

There is no way to modify boiler water treatment to prevent or control the trouble. When flat or prismatic glasses are affected replace them with mica-backed flat glasses. When tubular glasses are involved, try to obtain a more resistant glass.

Free Copies of Water Lecture Available

A limited number of free copies of "Your Most Important Raw Material," the Edgar Marburg Lecture by Dr. Everett P. Partridge, are now available. For your copy or for information on how the Hall System can help solve your particular water problems, write, wire or call address below.

Water is your industry's most important raw material. Use it wisely.

HALL LABORATORIES

DIVISION OF HAGAN CHEMICALS & CONTROLS, INC. • HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

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HEATING, VENTILATING

1 **Tubeaxial fans,** performance and dimension specs, are subject of 8-p catalog 1110-B. Charts show recommended stack sizes, maximum hp, maximum motor speed for variable stack velocity and air flow output. Westinghouse Electric Corporation, Sturtevant Div, 200 Readville St, Hyde Pk, Boston 36, Mass.

2 **Sound ratings,** other buyer info for gas-fired unit heaters are included in 8-p catalog 58. Unit location, mounting heights, performance specs are also covered. Grinnell Corporation, 260 W Exchange St, Providence 1, R. I.

3 **Mechanical draft fans** are discussed in 8-p brochure 1361. Describes centrifugal units for handling abrasive gases at elevated temperatures. Westinghouse Electric Corporation, Sturtevant Div, Dept T-315, 200 Readville St, Hyde Pk, Boston 36, Mass.

COMPRESSORS AND ACCESSORIES

4 **Centrifugal compressors** are described in 20-p bulletin 909. Construction, operating features are detailed, and typical applications listed. Includes photos, graphs and cutaways. American Standard, American Blower Div, Detroit 32, Mich.

5 **Heavy-duty** 1-p compressors ranging from 756 to 7392 cfm are topic of 8-p bulletin A-95. Includes a detailed sectional drawing, illustrations of all vital parts and features. Joy Manufacturing Company, Henry W Oliver Bldg, Pittsburgh 22, Pa.

6 **Compressor service applications** in the petroleum industry for 200-700 hp, high-compression gas engines are detailed in bulletins 119, 120. They include features, specs, rating curves. The White Motor Company, White Diesel Engine Div, Springfield, Ohio.

7 **Industrial compressor,** 100-hp model, is subject of 4-p bulletin E-274. Unit delivers 420 cfm at 100 psi. In-service photos, specs and a diagram are included. Davey Compressor Co, Kent, Ohio.

ELECTRICAL DISTRIBUTION

8 **Rigid steel conduit** advantages are outlined in 12-p bulletin RCP-940. Conduit in ½- to 6-in. sizes is described. Charts show dimensions and weights, packaging, cable capacity. Rome Cable Corporation, Rome, N. Y.

9 **Flexible cords** and portable cables are subject of 64-p manual 1108. Units are mold cured and neoprene sheathed, and data given includes dimensions, engineering info, splicing and terminating instructions. The Okonite Company, Passaic, N. J.

10 **Metallic tubing** is discussed in 12-p bulletin RCP-900. Covers applications, manufacturing info. Rome Cable Corporation, Rome, N. Y.

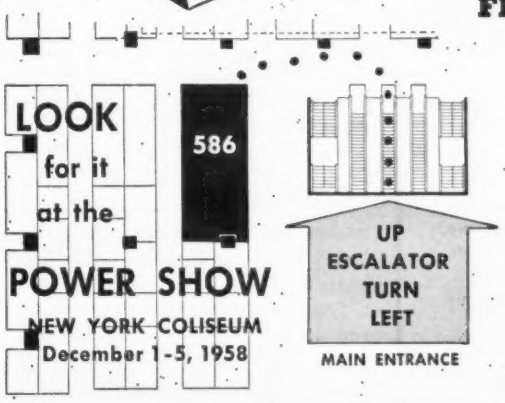
(*Continued on page 178*)

HERE'S YOUR *Complete* STEAM PLANT

Burns Oil or Gas or Both!

FEATURES of the **SUPERIOR** "COMPACT"

- One purchase, backed by undivided responsibility.
- Shipped completely assembled after factory tests to assure highest operating efficiency.
- More than 80% thermal efficiency guaranteed.
- 4-pass design provides 5 sq. ft. of heating surface per b.h.p.
- Induced draft fans which are built-in eliminate the need of an expensive chimney.
- Simple installation requires no special foundation.
- Clean, quiet operation.
- Heavy-duty, rugged construction assures long-lived dependability.
- Burner equipment to suit your fuel: gas, oil or both.
- Capacities from 20 to 300 b.h.p. for pressures up to 250 p.s.i., or for hot water heating. Write today for bulletin 1000C

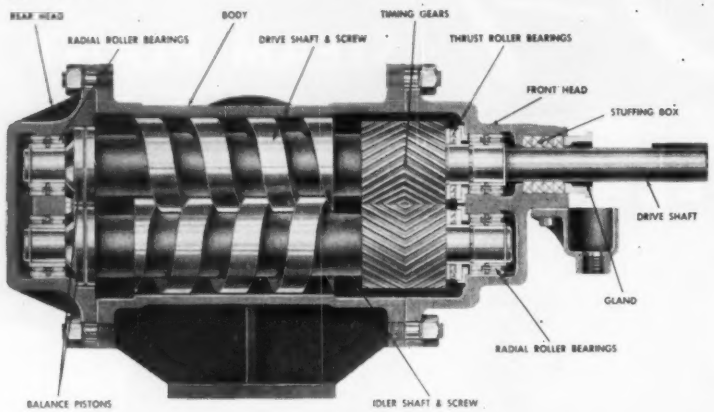


Specialists in PACKAGED BOILERS... exclusively

SUPERIOR COMBUSTION INDUSTRIES INC.
TIMES TOWER, TIMES SQUARE, NEW YORK 36, N.Y.

SUPERIOR
PACKAGED BOILERS

SIMPLICITY lowers the cost of this WARREN TWIN SCREW PUMP

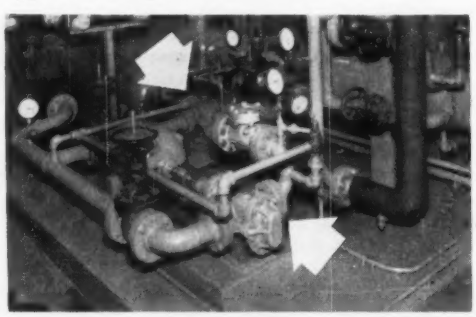


Here's an inside view of a high-speed screw pump that will do the work of other top quality rotary pumps costing twice as much!

Notice the simple construction of this Warren Twin Screw Pump, and the minimum number of parts. The compactness means low initial cost . . . and because no special foundation is needed, installation costs are minimized. No modification is required for vertical operation where floor space is extremely limited, or where the driver must be elevated to prevent flooding.

Maintenance of this efficient type TS pump is also economical. By removing the rear head only, rotating elements can be withdrawn *without disturbing the piping or motor,* and repair parts *that need no field machining* can be shipped immediately from stock.

Four sizes of type TS Screw Pumps are available for capacities to 550 GPM and discharge pressures to 350 PSI over a wide viscosity range. They are particularly suited for *fuel oil services* and other heavy duty oil services requiring a constant, pulseless flow. An ideal application is pictured below.



Two Warren Type 337TS Twin Screw Pumps on *fuel oil burner service* are shown in this installation at the Holyoke, Mass. Gas & Electric Department Plant.

WRITE FOR BULLETIN 255

for more detailed information about the TS Screw Pump that does the job for about one-half the cost.

CENTRIFUGAL · SCREW · RECIPROCATING · ROTEX

WARREN PUMPS, INC.

WARREN, MASSACHUSETTS

P-37

Expansion joints

Continued from page 109

duck reinforcing, clamped from the inside of the joint on the two bulbous end sections. When under vacuum, the web section bends inwardly. Thermal expansion compresses the joint and increases the deflection.

A vacuum of 27 in. Hg with 1.75 in. compression has made some webs deflect as much as 2 in. Baffles, integral with the clamping bars, prevent high-speed water droplets in the steam from hitting the bent-in web.

Comparisons. Each type of joint has its advantages and disadvantages. Rubber, for instance, should not be heated continuously above 180 F. Infrequent heating to 250 F during startups will reduce rubber life by about 5%. Cooling sprays might pay off to gain maximum life. Rubber must be protected from oil or it will deteriorate quickly.

All the joints, except the Phillips, are stressed so they must be worked within their limits. Design of flexing joints depends mostly on trial because they are difficult to calculate; the omega joint is an exception. Because of fatigue failure, copper is not the best material for expansion joints.

U-shaped and omega joints must be assembled and shipped in their final form. Usually the joint must be installed before either the turbine or the condenser. To replace the joint later, either the turbine exhaust must be removed or the condenser dropped. In contrast, the belt type may be installed or replaced through an access door in the condenser neck; the Phillips type may be replaced easily from the outside.

Fire hazards vary for the different types. Rubber is particularly vulnerable to fire. The omega joint has no rubber and the Phillips' small rubber section is protected in a pool of water.

Costwise, the omega and belt joints run about two-thirds of the Phillips joint. They cost somewhat less than spring supports for larger turbine-condenser units.

Omega joints have performed well for normal deflections. Usually they are shipped assembled and must be replaced, when needed, as a unit. This can be difficult for large units. The joint itself is not easy to make and has few builders. Field welding or repair

NEW... from K&M

EXTERNAL PILOT-OPERATED PRESSURE REGULATOR

fast-acting, accurate . . . tight shut-off even on dead-end service

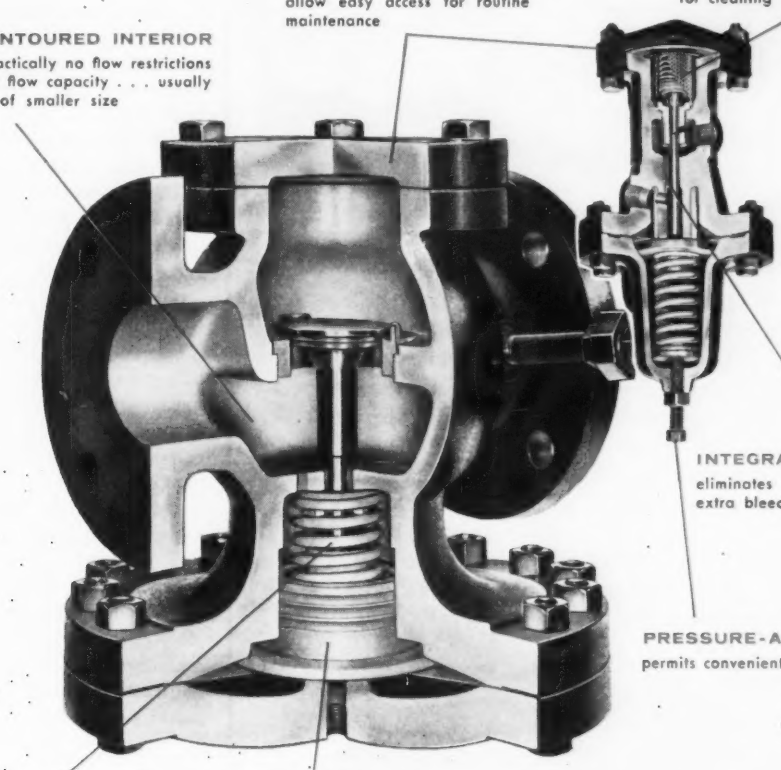
Examine it yourself . . . feature for feature. K&M has made a vast improvement in external pilot-operated pressure regulators.

It simplifies installations: *requires one less pipe line.* It offers lowest maintenance: *the result of good hydraulic and mechanical design throughout.* It gives excellent performance: *try one and compare with any other regulator of its type.*

BUILT-IN STRAINER
protects pilot from scale, dirt, other foreign matter, is removable for cleaning

BLIND FLANGES
on both main valve and pilot allow easy access for routine maintenance

CLEANLY CONTOURED INTERIOR
has no spider, practically no flow restrictions . . . gives greater flow capacity . . . usually permits economy of smaller size



INTEGRAL BLEED ORIFICE
eliminates need for installation of extra bleed line

PRESSURE-ADJUSTING SCREW
permits convenient external pressure setting

GUIDE PISTON
has balancing grooves which hydraulically center guide, prevent binding and side-thrust

CONTROL SPRING
is isolated from main flow stream for greatest protection

If you would like a more detailed, close-up look at K & M's new Type 471 External Pilot Pressure Regulator, send for Bulletin 471A.

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Design makes the difference: in over a thousand plants across the continent, Buell Cyclones have *proved* themselves more efficient than any other cyclones made. Buell's exclusive Shave-off port (A), traps the extra percentage of dust that ordinary cyclones lose. And large-diameter (B), custom-engineered design eliminates bridging, clogging, or plugging during operation, keeps efficiency high without interruption. Regardless of your present or planned plant layout, Buell equipment can be designed to solve your dust collection problems efficiently and economically. There's valuable information in a concise booklet, "The Exclusive Buell Cyclone". Write Dept. 50-L, Buell Engineering Company, Inc., 123 William Street, New York 38, N. Y.

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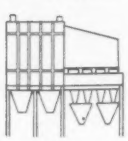
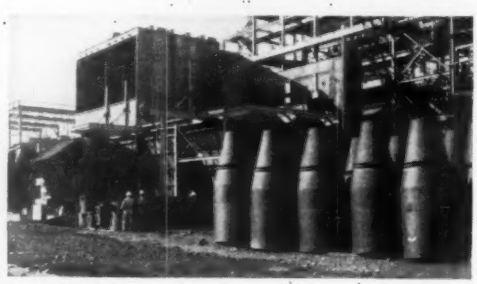


PRECIPITATOR-CYCLONE COMBINATIONS



Buell Cyclones before installation at a major plant.

buell

Experts at delivering Extra Efficiency in

DUST COLLECTION SYSTEMS

Expansion joints

Continued from page 168

is not too feasible since the thin stainless section requires inert-gas welding by specially trained weldors. Also the joint usually is not easily accessible.

Belt type joints have done well for many years and are much used today, photo, p 108. The joints can be easily installed and replaced, can absorb some misalignment and are reasonable in cost. They allow considerable expansion and need no access space from outside; this allows closer spacing of foundation piers. The joints are vulnerable to heat, fire and oil.

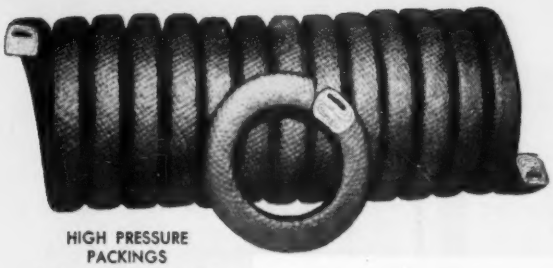
They must be replaced from inside and if the clamping blocks need tightening this must also be done from inside. Reactions on turbine exhaust should be checked under two conditions: (1) Under normal vacuum—any initial vertical stretch in the belt plus catenary loading of the belt will give a downward pull on the turbine-exhaust flange which adds to the vacuum load. (2) Under noncondensing operation—joint compression creates an upward thrust on the turbine-exhaust flange. The designer must place enough dead load above the expansion joint to prevent uplift exceeding the turbine-builder's specification.

Phillips joints can absorb large movements; water lubrication of the seal hose gives a practically zero friction load. Only a small amount of condensate supplied through a simple piping system seals the joint. Easy replacement of the sealing hose needs the least amount of outage time. The joint is less vulnerable to heat and fire damage than exposed rubber joints.

The joints cost more and need space on the outside for access. This either reduces the available exhaust section or calls for greater distances between foundation piers. Compact design of modern turbines makes the foundation design more difficult.

Hydro project near Anchorage, Alaska will have two 7500-kw turbogenerator units. REA has approved loans of $14 million for the project.

Mexico's FPC is using four portable 5000-kw gas-turbine units for emergency power along its systems. Mexico also uses mobile diesel units.



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Just as in the design of a new pump or generator, nearly every packing requirement dictates a unique set of parameters for its solution; change size, speed or temperature rating, for instance, and your needs will be different. That is why The Anchor Packing Company...with more than 50 years experience in serving industry...specializes in *designing the packing for the application*...good reason why Anchor packings are always efficient, more effective and longer lasting.

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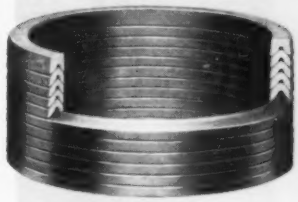

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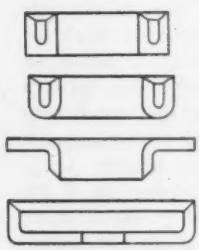

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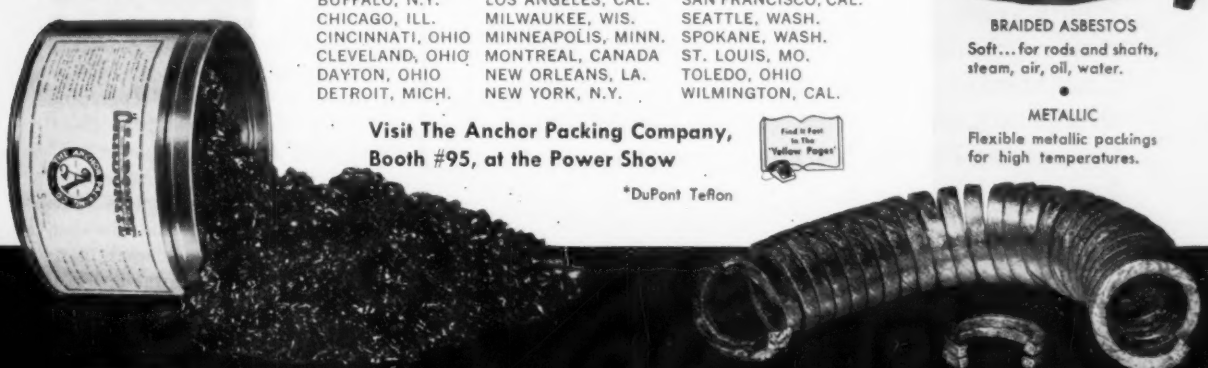

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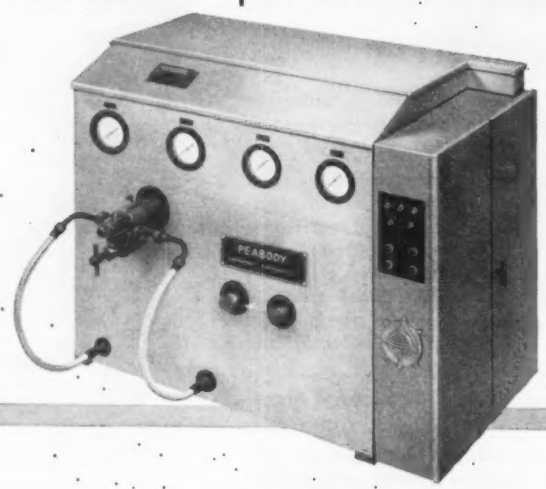

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My biggest boner...

I was shift foreman in a 2-unit 220,000-kw steam electric plant for two years before I learned my most important lesson.

Our No. 2 unit was down for its annual inspection. Watersides of our five closed feedwater heaters were to be acid cleaned by an outside contractor that morning.

We closed the feedwater supply valve to the boiler, installed a hose jumper between the third and fourth heater to bypass the feedwater pump. Both inlet and outlet valves were closed on the pump. We installed a 2-in. connection in the condensate line to the condenser on our steam-jet air ejector.

Condensate-discharge pump valves were closed. Idea was to circulate the acid-cleaning liquid through the heaters. Discharge of acid-cleaning pump was connected to line between condenser and air ejector. Return hose was connected to line between condenser and No. 1 heater.

Chemical truck arrived at 9 am and we told them to go ahead. After pumping for an hour, no acid had returned to the acid tank. I had contractor stop pumping while an operator helped me check all the valves in the system. We found the trouble: the valve on condensate-recirculating line had not been closed. So acid had been going into the turbine condenser all the time.

We closed the valves that were actuated by the condensate flowmeter and started pumping again. Half an hour later we checked the acid tank and found that acid was not returning to the tank. I stopped the pumping and called all available help to check the system again. You guessed it! Condensate-recirculating valve had a 2-in. nonrising stem bypass. This valve was two turns open. By then the acid solution was too weak to be effective, so a new load was ordered. That took time and held the job up, which added to my embarrassment.

That boner cost several hundred dollars. But I learned my lesson: never believe a valve to be closed until it's tried.

C R WALLACE, *Wilmington, N.C.*

Continued from page 119

of this is that the machine comes up to speed smoothly. Then, just before reaching full speed, it snaps into vibration. Another indication may be a pulsating vibration similar to Fig. 2. This occurs when machine's frequency and structure's natural frequency are very close and there's a heterodyne effect between the two.

At times some appendage, such as a steam pipe, may be sympathetic to the machine frequency and vibrate severely. This, in turn, may kick back causing the machine to vibrate severely. If it's near resonance you should brace the structure.

Bump test is way to find natural frequency of a machine part. Delivering a blow to the part sets up a train of damped oscillations. Frequency of these oscillations is the natural frequency of the part. This is a valuable time-saving test. Our instrument makes it very simple to carry out. If you bump test a machine shaft while it's stationary, it indicates its critical speed when running. Reason: Natural frequency and critical speed are same thing. Shown are some actual examples of bump tests.

Fig. 7 was taken on a rotor 9 feet between bearings and weighing 24,000 lb. Stepped shaft had a maximum diameter of 9 in. To make test the vibrograph was set for 10:1 magnification and held against the rotor close to its center. A blow with a sledge hammer on a piece of 6x6 in. wood held against the rotor set up the desired train of oscillations. You can see eight complete oscillations in the one-half second length of the frequency scale. This shows that critical speed was 960 cpm. It was much too close to operating speed and was causing trouble.

Fig. 8 shows a bump test on the shaft of a 200-hp vertical motor generator. Vibrograph was set for 20:1 as its extension probe reached through a ventilating hole to center of the shaft. Steel bar was placed against the shaft from the other side and given a hammer blow. Frequency of the train of oscillation was 4800 cpm —well above operating speed of 3600 rpm.

Cooling tower on a roof had severe vibration and it looked as if a large balance weight on the fan would be needed to correct it. But it was bal-

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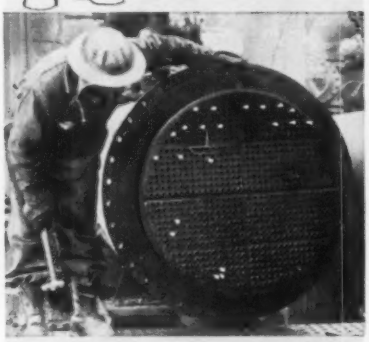

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NUPRO engineers have utilized modern design principles to develop a tube plug of greater reliability and easier installation. The efficient design of this plug incorporates a dome head, assuring concentricity in the tube and a leak-tight seal under corrosive, high pressure and extreme temperature conditions. An optimum taper of 1°47′ for sealing and preventing tube damage was arrived at after extensive field tests. NUPRO Tube Plugs are available in Hastelloy, Zirconium, Cellulose Fibre, Brass, Carbon Steel, Inconel, Monel, 316 Stainless Steel or any machineable material, assuring a wide range of compatability to meet your needs. Available for immediate delivery for tubes ½" to 1½" dia. from local distributors' stocks througout U.S.

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"Our condenser was down... production held up... we got specialized NUPRO tube plugs from Nuclear Products Co. in less than 24 hours... and we were back in full production in less than 30 hours."

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Vibration

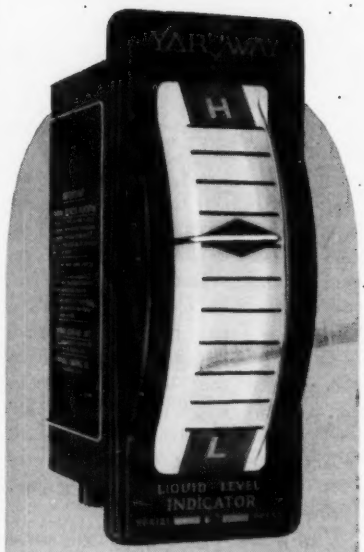
Continued from page 173

anced with a very small weight because of resonance in some part of structure. A vertical water pipe was suspected. Vibrograph was set for 5:1 magnification and the pipe hit by hand. Resulting train of oscillations showed a frequency of 380 cpm. Fan rotational speed was 390 cpm. Pipe was close enough to resonance to vibrate violently, which kicked back into the tower. Bracing the pipe suppressed the vibration of the whole structure without balancing.

Fig. 9 shows a bump test on a beam which betrays two frequencies at the same time. Widely spaced oscillations show the linear natural frequency of 450 cpm. A blow also set up torsional oscillations with a natural frequency of 1800 cpm which appear superimposed upon the low frequency. In analysing, the low and high frequencies are counted off separately on the frequency scale. Here the higher frequency has died out while the lower frequency persists, indicating a higher damping factor for the torsional mode.

Complex vibrations. When a vibration record departs from sine wave form, its interpretation is often simpler than it appears at first. Usually the record isn't a confused trace that defies visual analysis but, rather, a pattern with definitely recognizable features. Let's examine Fig. 10, taken on an induction motor. First, there's the regular wave pattern caused by motor unbalance, with amplitude of 0.005 in. Counting frequency we find 29 peaks in one-half second, showing that motor is running at 3480 rpm. Too, as motor vibrates steadily at high frequency it's being displaced rhythmically at low frequency of about 4 per sec.

A second harmonic is recognized by dip in one side of each wave. But this dip doesn't stay in one place. It climbs up and down the wave, indicating that it must be out of step with rotation. Besides, its rate of travel up and down the wave is the same as the slow pulsations. This shows that cause of each is the same. Second harmonic represents the magnetic pulses occurring each 180 deg of the 60-cycle line frequency. Since these are slightly over twice rotational frequency, they cause modulation of the mechanical unbalance wave at



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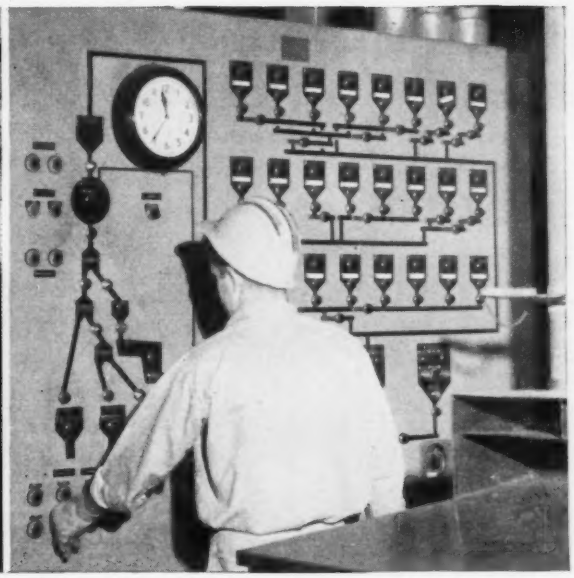

LEFT: This was the executive headquarters of the industrial water treatment industry at the turn of the century. From here, Robert F. Carr, president, directed the operations of Dearborn Chemical Company.

RIGHT: Today, in some 21,000 square feet of ultra modern laboratory space, Dearborn scientists solve water treatment problems arising in industry throughout the country and develop exact correctional formulas which are compounded at Dearborn's 80 acre Lake Zurich operation in the only completely automated plant of its kind in the world. Illustrated is one of the plant's electronic push-button controls from which a Technician can set up any desired formula for completely automatic ingredient weighing, mixing and packing.

Water Treatment—It All Started 71 Years Ago with Dearborn Chemical Company

There is always a first—a pioneer in everything. And in the water treatment industry, which today serves virtually every major user of steam for heat or power, it was Dearborn Chemical Company.

Actually the scientific water treatment industry was born in 1887 over a cook stove in a barn on Chicago's South Side. There, a young chemist, William H. Edgar, after a series of experiments prepared the first chemical feedwater treatment.

His interest had been aroused by chance. Strolling through Chicago's loop, he stopped to watch a steam boiler being removed from a large office building. Inquiring as to why such a costly item was being discarded, he was told that heavy deposits of scale made it unusable. Convinced of the feasability of chemically removing such scale, he obtained some scrapings for analysis and subsequently developed a formula for removing them and preventing their reformation. He took this to the operating engineer of the office building and the world's first scientific water treatment sale was made.

Shortly afterwards, Mr. Edgar and a chemist associate, Frank E. Mariner formed the firm of Edgar and Mariner and set up laboratory facilities for the analysis of water and the development of chemical formulas to scientifically improve boiler conditions and provide higher efficiency in steam produetion. Later, Robert F. Carr, a chemist, joined the firm which subsequently became Dearborn Chemical Company.

From basic feedwater treatment, it was a natural step to the development of antifoam products such as Dearborn's patented polyamides, and other products to condition sludge, prevent carry-over and protect against the formation of scale. Simultaneously, the engineering aspects of water conditioning gained increasing attention and the growing Dearborn Company designed valves, fittings, and larger items such as water softeners and deioning plants to permit proper and economical applications of water treating chemical formulas.

Today, service engineers from Dearborn constantly serve customer operations in the field and they are continually consulted by power engineers throughout the world for solutions to problems connected with all types of industrial usage of water.

As Valid Today As in 1887

Incorporation papers for the first water treatment company drawn in 1887 state that the purpose of the company shall be: "manufacturing and selling Feed Water Treatment, based on the theory proved by actual test that practically all waters used for steam making purposes, from whatever source, need chemical treatment to be of the greatest effectiveness and that such treatment to be of the greatest value must be based on the individual conditions surrounding each case; such determinations being made by chemical analysis of the water in use and information as to the source of supply, type of boiler, etc."

—From Dearborn Chemical Company's Official Files

For information on Dearborn Engineering and Consulting services write: Dearborn Chemical Company, Merchandise Mart Plaza, Chicago 54, Illinois

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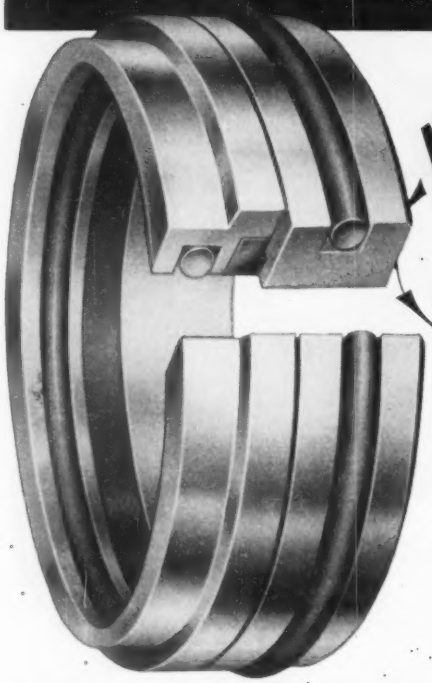

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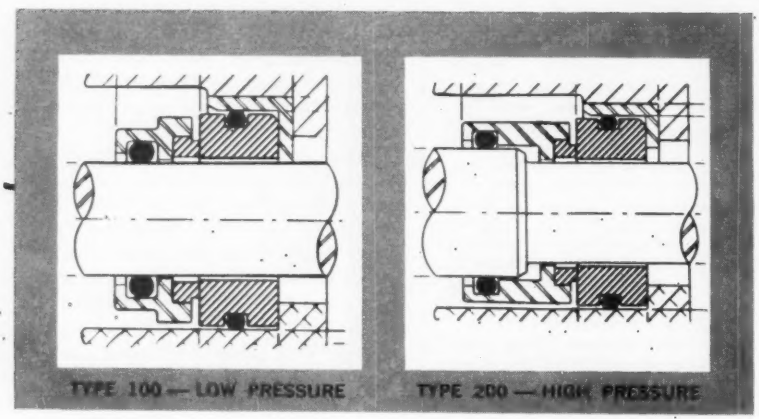

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America's Oldest Manufacturer of Mechanical Packings

Continued from page 174

about 4 cps. This shows graphically the pulsations often heard in an induction motor plus the characteristic ac hum.

Transient shown in Fig. 1 temporarily distorts the wave form. Check if it happened once or more often. If repeated, was it at regular intervals? If so, measure the space between impulses and get frequency. Then work back and find the cause. Fig. 11 shows vibration of a machine frame from belt-joint slap. Impulses occur at nearly 2 per sec. But why the following oscillations? Each belt slap has started structure vibrating at its natural frequency. So before these oscillations damp out, they're caught up by next slap. Frequency of oscillations will be the same after each slap. Since this is a very common pattern, it may arise from any intermittent disturbance.

A second harmonic is common and easily recognized. It's typically shown in Fig. 3; and can be recognized again in Fig. 12. But there's a striking difference. In Fig. 12, the second harmonic is out of step with the fundamental frequency. Note how the supplementary wave climbs rhythmically up and down the main wave. It was this very point which gave a quick diagnosis of the origin of the second harmonic.

Record was taken on a tubular wire-stranding machine with probe contacting rotating tube. Tube was supported on rollers slightly less than one-half tube diameter. So any vibrations set up by roller wouldn't stay in the same phase with tube vibration because ratio wasn't exactly 2:1. Here one roller was eccentric. Had the second harmonic been from a tube worn oval, it would have persisted in the same phase with the fundamental and looked more like Fig. 3.

Chatter caused by loose members shows up plainly in vibrations records and generally produces saw teeth in the curve. Of course, an infinite variety of records may be produced but, generally, we are interested only in main characteristics.

Start looking for typical signs of trouble in a given type of machine. You'll learn to recognize them very quickly. A little practice and you'll find the vibrometer a big help.

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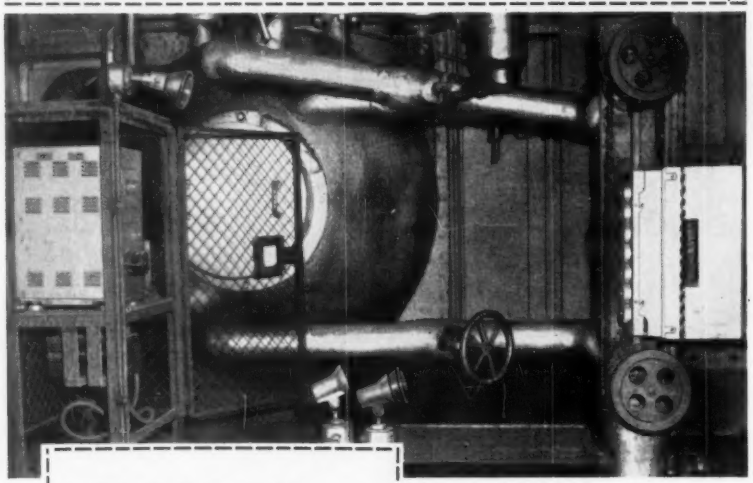
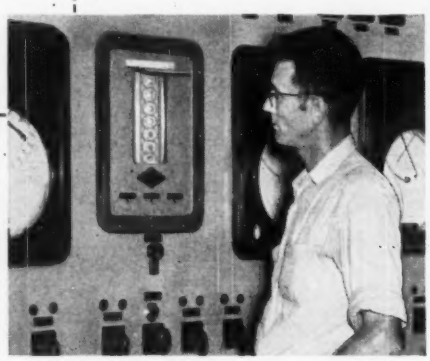


Diamond Television camera has been SEEING water level in boiler for almost nine years.

75,840 Hours of Operation

(with Original Camera Pickup Tube)



Operator at boiler board SEES boiler water level on Diamond Television screen.

At the Wood River Station of the Illinois Power Company, this Diamond "Utiliscope" has been in continuous operation since 1949. It has a job where dependability is all important; watching the water level in a big central station boiler. The original camera pickup tube is still in service . . . a record of more than 75,840 hours (nearly nine years) of operation. Routine maintenance is the only service required since installation.

Diamond "Utiliscope"—Heavy Duty Television—is dependable, durable, resistant to time and difficult operating conditions. It is saving money and improving operation in steel mills, foundries, mines, and a wide variety of manufacturing plants. Use the coupon below to obtain more information.

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Free literature

Begins on page 165

11 **Cable caliper,** a plastic device for measuring diameters of cables, checking which size jacket to use, will be supplied free by the company. The Zippertubing Co, 752 S San Pedro St, Los Angeles 14, Calif.

12 **Synchronous motors** and controls are listed in 27-p brochure B-7292. Booklet summarizes types and features, discusses power-factor correction, selection, application. Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

ELECTRICAL APPLICATION

13 **Conductor slide rule** is an aid in selecting dimensions of aluminum foil or sheet for use in strip-wound electrical coils. Aluminum Company of America, 1501 Alcoa Bldg, Pittsburgh 19, Pa.

14 **Electric scale-control** unit is discussed in 4-p bulletin. Diagrams show installation in boiler, hot-water tank, cooling system, evaporative condenser. Aqua Electric Scale Control Inc, 2026 E 22nd St, Cleveland 15, Ohio.

15 **Weather-protected motor** is topic of 6-p bulletin 2550. Includes cutaways, features, specs. The Louis Allis Co, 427 E Stewart St, Milwaukee 1, Wis.

MAINTENANCE

16 **Hydraulic jet cleaners** for walls, floors, process equipment are covered in 8-p bulletin 424-B. Includes photos, a diagram. Sellers Injector Corporation, 1600 Hamilton St, Philadelphia 30, Pa.

17 **Emergency** and maintenance repairs with "plastic steel" are listed in 8-p bulletin 3. Case histories describe uses of 80%steel-20%plastic mixture. Devcon Corporation, Danvers, Mass.

18 **Block insulation** is detailed in 8-p brochure. Amosite asbestos-base block insulation can withstand up to 1850 F. Aber Company, Inc, Box 2535, Houston, Texas.

19 **Glass-fiber pipe** insulation for subfreezing to 350 F temperatures is subject of 8-p folder WPN-2. L.O.F. Glass Fibers Company, 1810 Madison Ave, Toledo 1, Ohio.

20 **Industrial insulation** handbook has 16 pp. Book describes fundamentals for the insulation buyer, foreman or maintenance superintendent. Aber Company, Inc, Box 2535, Houston, Texas.

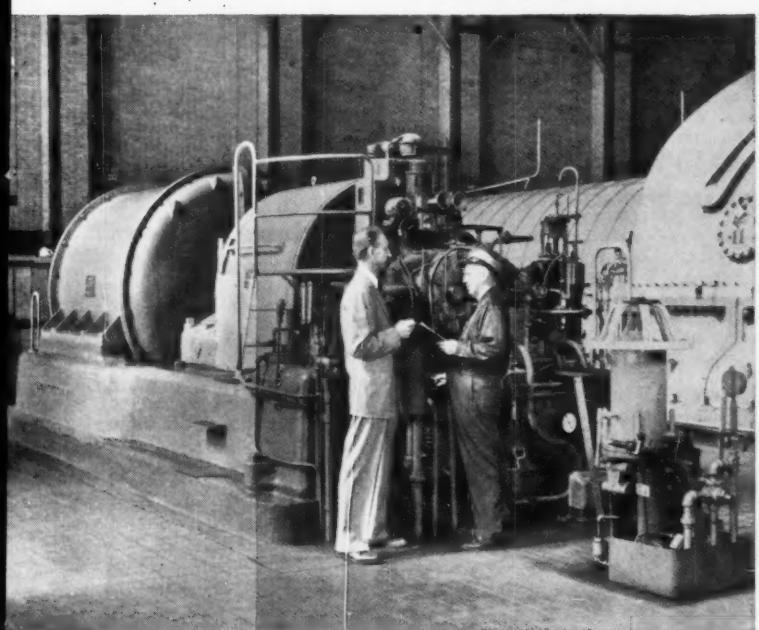
MECHANICAL POWER TRANSMISSION

21 **Dry fluid drives** and couplings are described in 24-p catalog. Engineering drawings, product photos, installation pix show how units solve various drive problems. Dodge Mfg Corp, Mishawaka, Ind.

(*Continued on page 180*)

Report from Wisconsin Electric Power Company

HOW THE ONLY OIL WITH LIFE-OF-TURBINE GUARANTEE IS DOING AFTER 27 YEARS



Standard Oil's Robert A. Guis and Lakeside Station superintendent, C. E. Thielman, inspect records of Turbine 12, which has been operating with NONPAREIL Turbine Oil for 27 years. Years of experience providing technical service and an engineering degree qualify Bob Guis for work with utilities on turbine lubrication. Bob has an engineering degree from the University of Wisconsin plus 18 years of this kind of work behind him. In addition, he has completed the Standard Oil Sales Engineering School.

Situation: On February 23, 1931, Wisconsin Electric Power started Turbine 12 at its Lakeside Station – a 7,700 kw. General Electric. The 550-gallon turbine oil reservoir was filled with NONPAREIL. A Standard Oil lubrication engineer was there to supervise the fill. After 30 days a framed certificate was furnished the utility. This certificate guaranteed that the NONPAREIL Turbine Oil would never exceed a level of acidity of 0.15 mg. KOH/g. for the life of the turbine.

What has happened: Analyses of oil samples have been made at regular intervals since the start-up date. The acidity level of the oil now is the same as the day it went into service –0.06 mg. of KOH per gram of oil. In the 27 years since NONPAREIL Turbine Oil was installed, Wisconsin Electric Power has added steadily to its generating capacity. NONPAREIL Turbine Oil has been installed in all turbines.

What to do: Get more information about NONPAREIL from your nearby Standard Oil industrial lubrication specialist in any of the 15 Midwest and Rocky Mountain states. Or write **Standard Oil Company (Indiana), Chicago 80, Illinois.**

Quick facts about

NONPAREIL Turbine Oil

- Will not permit formation of harmful acids
- Will not permit formation of sludge or oil varnish
- Will maintain good demulsibility or water separating characteristics
- Has high resistance to foaming
- Contains adequate rust inhibitor

You expect more from STANDARD and get it!

SEE the

Barnes and Jones

Instantly Renewable

Steam Trap

The "Trap Within A Trap" — for instant "on the spot" repair — Ideal for preventive maintenance.

BOOTH 641
POWER SHOW
COLISEUM, N. Y.

See the ONE PIECE "Cage Unit" that is revolutionizing maintenance and repair, and guaranteeing uniform capacities for Fast Heat Up and Peak Production.

Barnes & Jones, Inc.
34 Crafts St.
Newtonville 60, Mass.

Free literature

Begins on page 165

22 **Shaft-mounted** speed reducers are listed in 10-p engineering manual B-7238. Selection, hp ratings, dimensions, construction, installation and maintenance are some factors discussed. Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

23 **Flexible couplings** in ten sizes are covered in 8-p bulletin 10100A. Photos, tables, diagrams included. T B Wood's Sons Co, Chambersburg, Pa.

INSTRUMENTATION

24 **Process instruments** available for quick shipment are topic of 52-p catalog 2. Indicators, transmitters, recorders and controllers are among units listed. Graphs, tables, photos illustrate features. Fischer & Porter Co, 941 Jacksonville Rd, Hatboro, Pa.

25 **Steam meter** for 1- to 1½-in. lines is discussed in 8-p bulletin 400-P25. Cross sections, dimensional drawings, capacity and accuracy tables are given. B-I-F Industries, Inc, Builders-Providence Div, 345 Harris Ave, Providence, R.I.

26 **Recorders,** recording controllers, indicators are described in 12-p bulletin GEA-6792. Application data, specs, dimensions included. General Electric Company, Schenectady 5, N. Y.

PIPING, VALVES, SPECIALTIES

27 **Compression type packings** are discussed in 24-p catalog. Photos, drawings illustrate constructions available, various services. E F Houghton & Co, 303 W Lehigh Ave, Philadelphia 33, Pa.

28 **Tubing** made of beryllium-copper is topic of 6-p data memorandum 7. Describes mechanical and physical properties, applications, corrosion resistance. Superior Tube Co, 1778 Germantown Ave, Norristown, Pa.

29 **High-velocity** valve attenuators are subject of 24-p bulletin K33-A. Graphs, diagrams, charts provided. Connor Engineering Corporation, Danbury, Conn.

30 **Stainless-steel pipe** fittings are covered in 86-p master reference volume. Technical section includes info on manufacturing standards, specs, welding and corrosion resistance tables. Ladish Co, Cudahy, Wis.

31 **Valve-regulator** maintenance is discussed in 16-p manual 1099. Typical installations, mounting arrangements and piping are shown. Rockwell Manufacturing Company, Meter & Valve Div, 400 N Lexington Ave, Pittsburgh 8, Pa.

32 **Steel valve research** labs are shown in 32-p booklet. Processes

ALLIS-CHALMERS

ALLIS-CHALMERS

NEW brochure of ideas for modernizing

This booklet is based on the premise that modernization can start anywhere in your plant. It can be a single machine or operation . . . a better way of getting variable speed . . . a faster way to braze . . . or a newly available replacement. In fact, this type of updating is far more common than the sweeping change.

Get a copy of "59 ideas for modernization in '59" from your nearby A-C office or write Allis-Chalmers, Industries Group, Milwaukee 1, Wisconsin.

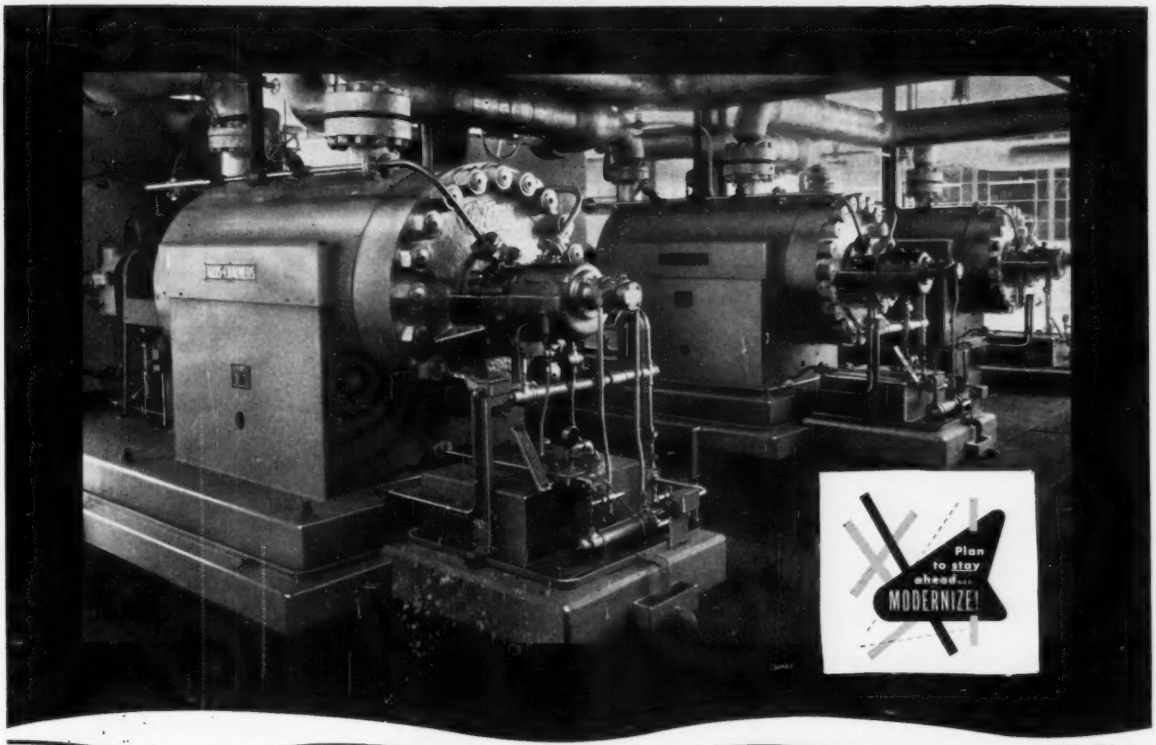
Examples of updating!

New motor development may eliminate premiums you've been paying for specially protected motors.

Electrical modernization includes placing substations close to machines being served.

ALLIS-CHALMERS

A-5850



There's NO radial thrust in Allis-Chalmers boiler feed pumps

Result: *Smoother running*

SEE HOW Allis-Chalmers boiler feed pumps are constructed. The above model is available for inspection right in your own office. Call your A-C representative or write us.

. . . and this Allis-Chalmers design also pays off in uniform ring and bushing clearances. Balanced thrust also increases the life of close clearances and packing because shaft vibration is eliminated.

In addition to balanced thrust, A-C barrel-type boiler feed pumps are finding ever-greater use in power installations for these reasons:

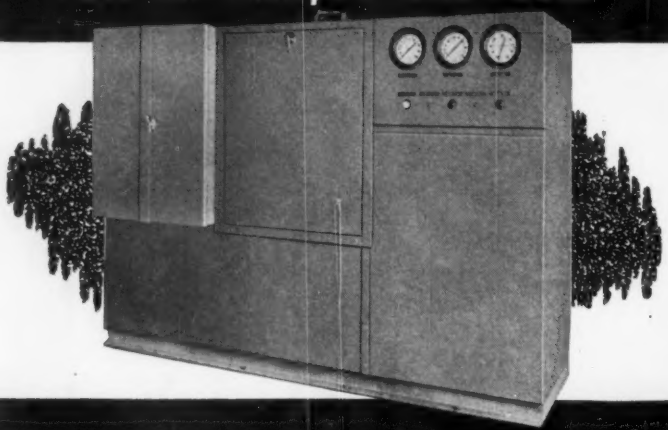
- First stage has twin single-suction impellers to give low NPSH requirement for highest efficiency under fluctuating loads.
- Expansion joint and shaft seals are brought to outside of pump where they may be easily inspected and maintained.
- You get choice of gland sealing in entire line of pumps from 300-5000 gpm, 1200-4000 psig.

Contact your A-C representative, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS A-C ALLIS-CHALMERS

A-5708

NOW - Steam Atomizing with NATIONAL AIROIL Packaged Firing Units FOR OIL AND/OR GAS FUELS



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● Fully Automatic ● Low Fire Start ● Electric-gas Ignition ● Modulating Fire Control ● Damper Sequence Control ● Forced Draft Combustion Air ● Electronic Combustion Safety Supervision ● Mechanical Atomizing — Steam assisted internal mixing oil burner ● Ring or Cylindrical type Gas Burner for gas fuel ● Fire tested before shipment.

NOW . . . with the new Series 20 Packaged Firing Unit you can have all the advantages of the outstanding Dual Stage burner in a completely packaged unit equipped with the latest in electronic safety controls to give *automatic* start, *automatic* modulation, *automatic* shutdown.

Series 20 Packaged Firing Units are factory fire tested, ready for immediate and low cost installation in your furnace room. They need only oil, gas, steam, draft and electrical connections—everything else needed for fully automatic burner operation is there.

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Units may be used with any standard boiler or furnace under natural or induced draft, or with pressurized boilers—in which case the unit provides sufficient forced draft to overcome draft loss through boiler. Where a high chimney or induced draft fan is used, an automatic damper motor is furnished to provide a constant furnace draft during operations; and a reduced or zero draft during shutdowns.

Preventative Maintenance consists chiefly of keeping the burner gun clean, with periodic inspection and cleaning of strainers and safety devices. This minimum maintenance will give your engineer or fireman extra time to attend to blow-down, soot-blowing, or to check operations and efficiency of plant and auxiliary equipment.

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When used in conjunction with a National Airoil Fuel Oil Pumping and Heating Unit (Bulletin No. 40) a most reliable combination results.

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Main Office & Factory: 1250 EAST SEDGLEY AVE., PHILADELPHIA 34, PA.

SOUTHWESTERN DIVISION 2512 SOUTH BOULEVARD, HOUSTON 6, TEXAS

Free literature

Begins on page 165

for making flow studies, stress analyses, temperature tests are illustrated. Edward Valves, Inc, East Chicago, Ind.

PUMPS

33 **Heavy-duty rotary pumps** are described in bulletin 170. Basic types shown have internal antifriction bearings, external antifriction bearings, or jacketed head. Blackmer Pump Company, Grand Rapids 9, Mich.

34 **Reciprocating pumps,** for chemical proportioning and power service, are subject of catalog 758. Units have capacities from 2cc per hr to 675 gph, pressures to 4575 psig. Jaeco Pump Company, Villanova, Pa.

35 **Centrifugal pumps,** single-stage double-suction units with horizontally split cases, are topic of 16-p bulletin 721.6. Gives sectionals, charts, specs, construction details. Goulds Pumps, Inc, 47 Black Brook Rd, Seneca Falls, N. Y.

WATER TREATMENT

36 **"Handbook of Demineralizing"** is title of 40-p book 5800. Compares various methods of treatment—demineralizers *vs* evaporators, different types of cation and anion exchange materials, operating costs. Includes flow diagrams, installation photos. Cochrane Corporation, 3107 N 17th St, Philadelphia 32, Pa.

37 **Feedwater equipment** design and treatment methods are discussed in 8-p technical reprint T-161. Hot process-hot zeolite and demineralization are described. Graver Water Conditioning Co, 216 W 14th St, New York 11, N. Y.

38 **Zeolite softeners** are covered in 12-p bulletin. Charts and diagrams aid selection. General Filter Company, Ames, Iowa.

39 **Deaerating systems,** boiler-feed systems, power-plant boiler-feed pumps, other accessories are subject of 20-p catalog 55-C. Selection guide helps plant owner choose best system. Tables, cutaways included. Fred H Schaub Engineering Co, 2110 S Marshall Blvd, Chicago 23, Ill.

WELDING

40 **Backing rings** are topic of 12-p spec sheet 58-2. Illustrates various types of rings, gives simplified welding procedure. The Robvon Backing Ring Co, 675 Garden St, Elizabeth, N. J.

41 **Welding supplies** and accessories catalog has 52 pp. Illustrated with 100 photos, book covers, fluxes, rods, protective clothing, electrode.

(*Continued on page* 186)

Approximate Service Limit Brand
3200°F. Castolast (Castable)
3100°F. H-W High Alumina Castable
Apache (Plastic Fire Brick)
3000°F. Chromepak (Casting Mix)
H-W Super Plastic Fire Brick
Apache G (Plastic Fire Brick with Graphite added)
2900°F. H-W Black Patch (Plastic Fire Brick)
2800°F. Harcast (Castable)
2700°F. H-W Super Castable
2600°F. H-W Lightweight Castable 2600
Harchrome (Castable)
H-W Chrome Castable
2500°F. H-W Standard Castable
H-W Periklase Castable
H-W Baffle Mix (Castable)
2400°F. H-W Extra Strength Castable
2300°F. H-W 85 Lightweight Castable
2200°F. H-W 56 Low Iron Castable
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can assure the proper selection for maximum life and economy

In addition to the wide range of service temperature limits as here illustrated, these monolithic refractories possess the many different combinations of physical and chemical properties needed for best protection against widely diversified destructive factors. From these brands the best balanced selection can be made for adequately withstanding the most severe operating conditions. Some examples of the many destructive influences against which maximum resistance is needed, are: corrosion by slags, fuel ash and various other fluxes; thermal shock; disintegrating action of gases; erosion by molten metals and slags; mechanical stresses at the high working temperatures.

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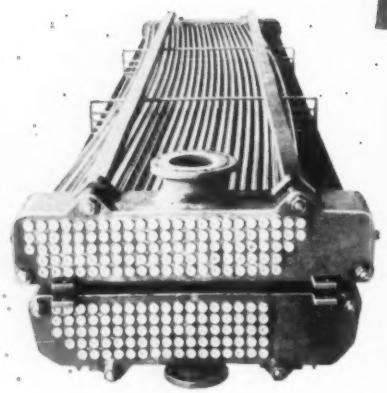
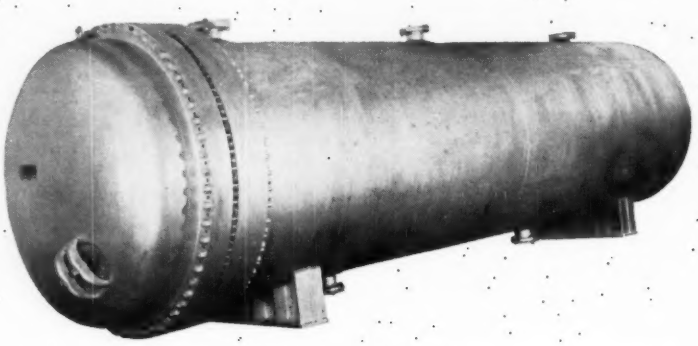
TYPICAL FURNACE APPLICATIONS: ARCHES • ASH PITS • BOILER SETTINGS • BREECHINGS • BURNER BLOCKS • BAFFLES • CATALYTIC REACTORS • DOOR LININGS • DUCTS AND PIPING • HEARTHS • INSULATION • KILNS AND CARS • LADLE LININGS • ROTARY KILN CHAIN SECTIONS • SOAKING PIT COVERS

G-R designed for power plants



Photograph of G-R Bentube tube bundle showing the initial bow of the tubes. Temperature changes vary the magnitude of the bend and the resultant flexing sheds scale from the tubes.



G-R Scale-Shedding Evaporators

G-R Bentube Evaporators provide boiler feedwater guaranteed to highest purities, long service life and minimum maintenance.

Highest purity dry vapor results from the use of a patented centrifugal moisture separator, large vapor space for moisture disengagement and splash baffling.

Long life and low maintenance are provided by a number of design features. G-R's exclusive Bentube design sheds scale through the controlled expansion of the tubes. This Bentube construction also offers easier tube cleaning and replacement since no U-bends are used.

Available in three designs for moderate, high and low capacities and pressures, G-R's 80-plus years of heat exchanger experience assure you of highest overall quality.

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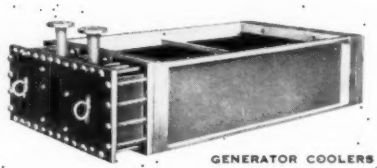
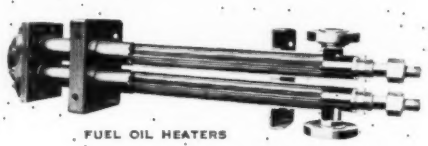
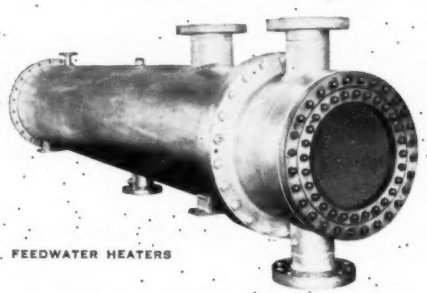
G-R Designs for Power Generation



GENERATOR COOLERS



FUEL OIL HEATERS



FEEDWATER HEATERS

- Evaporators • Air Preheaters • Fuel Oil Heaters
- Storage Tank Oil Heaters • Drain Coolers
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- Generator Coolers • Lubricating Oil Coolers

HEAT EXCHANGE EQUIPMENT FOR THE POWER INDUSTRY GR 387

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GENERAL PRECISION EQUIPMENT CORPORATION GPE

THE GRISCOM-RUSSELL COMPANY • MASSILLON, OHIO

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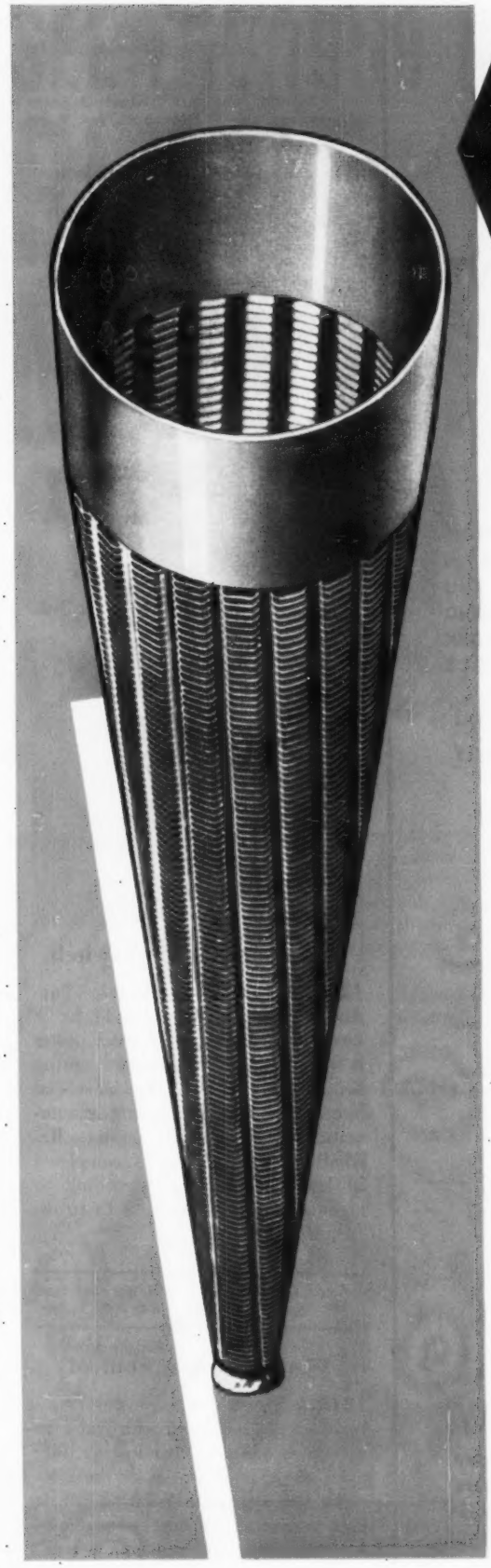


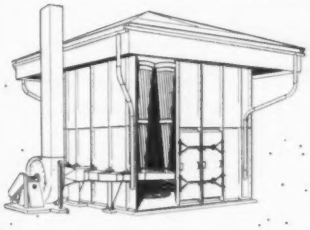
with this INSTALLATION

TURBO-BLOWER blade wear is... CHECKED!

With this Green AERODYNE Dust Collector, turbo-blower blade wear is sharply reduced.

Green AERODYNE Dust Collectors reduce coke breeze, coal dust, ferrous oxides and other abrasive dusts that wear out high-speed turbo-blower blades.

AERODYNE Dust Collectors are also used to clear combustion air for gas turbines. Oil bath and other types of filters requiring constant maintenance are eliminated by AERODYNE, as the collected dust is returned to the atmosphere. Dust disposal problems are eliminated.

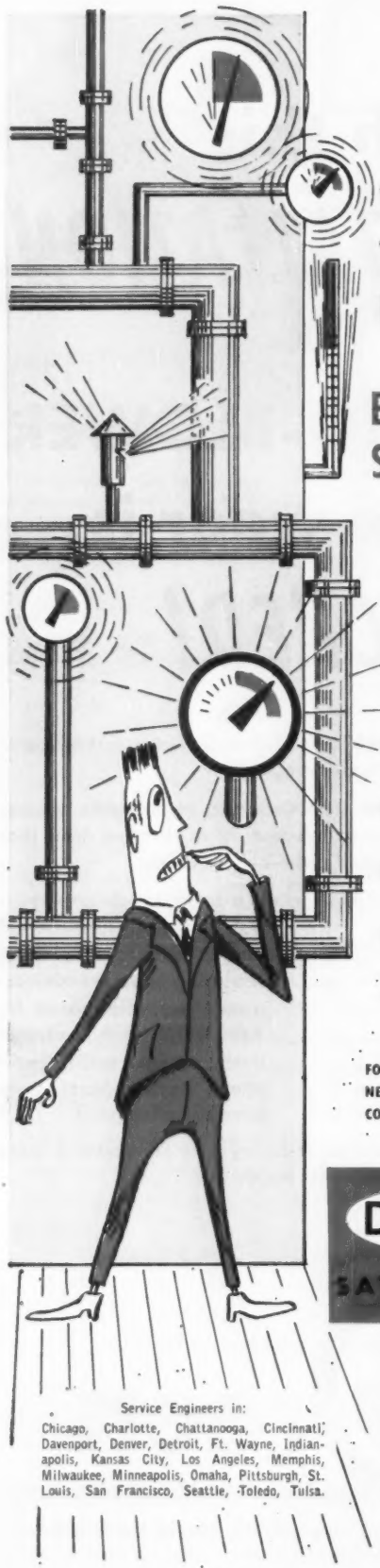


You will find this wear-reducing story of interest. A word to Green will bring you the details.

Green

THE GREEN FUEL ECONOMIZER CO., INC.

BEACON 3, NEW YORK



WATER TREATMENT PROBLEMS?

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WHATEVER YOUR PROBLEM, CONSULTING WITH DEADY WILL SAVE YOU TIME, CONFUSION AND COST. YOU CAN WORK WITH ONE SINGLE SOURCE FOR:

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Free literature

Begins on page 165

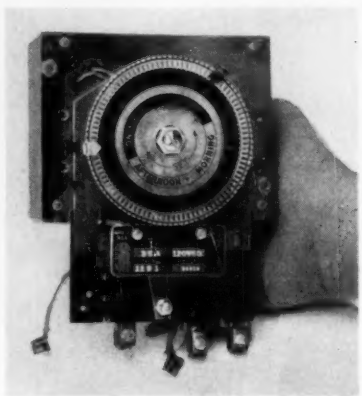
holders, etc. Air Reduction Sales Company, 150 E 42nd St, New York 17, N. Y.

41 **Hard-surfacing** fact file gives data on 88 types and sizes of electrodes and rods. Info is listed on reference cards. Metal & Thermit Corporation, Rahway, N. J.

42 **Submerged arc** and inert gas welding wire is discussed in 4-p folder DH-402B. American Chain & Cable Company, Inc, Page Steel & Wire Div, Monessen, Pa.

Equipment news

Begins on page 152



Reserve-power time switch

1211 • Unit will maintain "on-time" operation for up to 17 hr in case of power failure. Reserve power is provided by a powerful spring contained with the motor in special housing behind dial. Spring is automatically, electrically wound. Rewinding after outages is completed in less than two hr, according to manufacturer.—*Tork Time Controls, Inc, Mt Vernon, N. Y.*

For more details on these items, use post cards p 165. Identify your request with item number.

Wet-water dust control

1212 • "Do-it-yourself" dust control formula is diluted with water in a ratio of one part chemical to 1000 parts water, and sprayed on the dust-producing aggregate. Solution can be used to control coal dust in car dumping, truck dumping, crushing, screen-

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CLEVELAND PUBLIC AUDITORIUM
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Your top investment in plant efficiency! More than 350 leading manufacturers will show machines, equipment, and services to cut costs, improve plant operations. You'll hear and talk with outstanding experts, get hundreds of dollar-saving, method-bettering ideas — in four profit-packed, on-the-job days.

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Communication Systems
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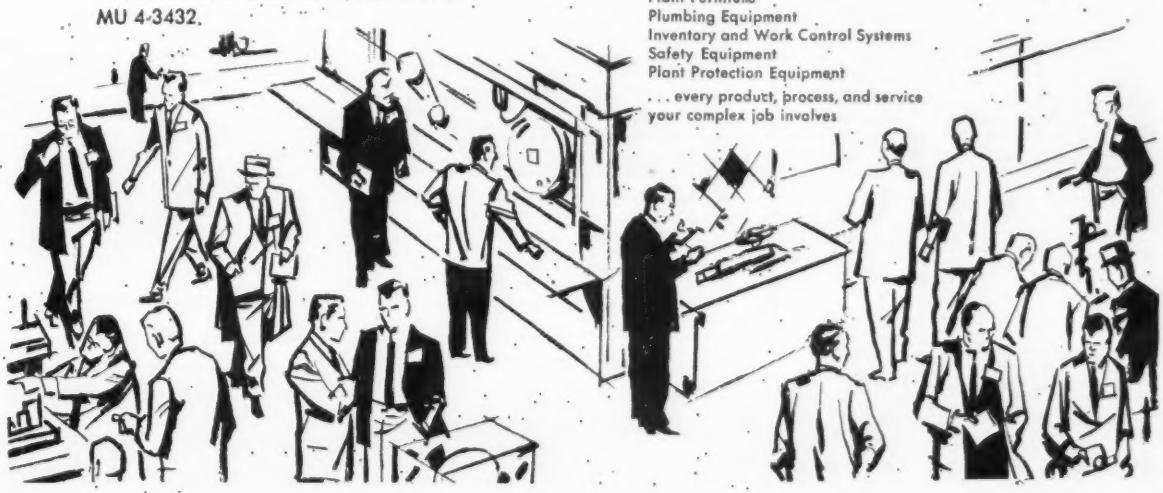
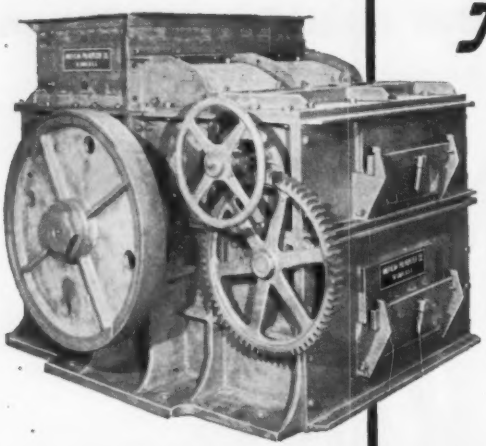
Storage Equipment
Plant Furniture
Plumbing Equipment
Inventory and Work Control Systems
Safety Equipment
Plant Protection Equipment

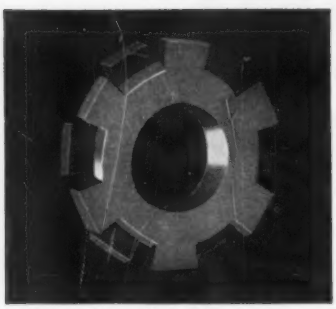
. . . every product, process, and service your complex job involves



BETTER COAL CRUSHING CONTROL BECAUSE IT'S BUILT BETTER . . .

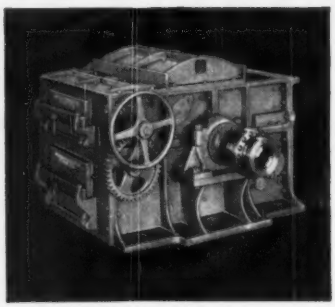
American ROLLING RING COAL CRUSHERS





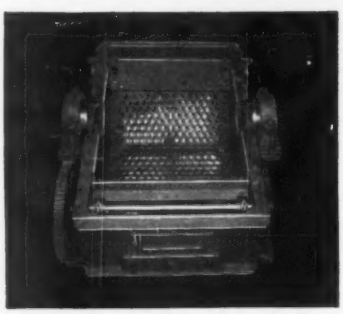
1 Patented Shredder Ring

American-originated feature that splits coal instead of smashing it—for uniform sizing, minimum fines. Result: Americans run at slow speeds, with savings in power and maintenance. No cams, shear pins, toggles.



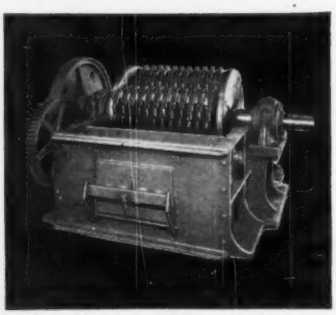
2 Heavy-Ribbed Steel Frame

Bearing pedestals are cast integrally with lower side frames. Sectional design for easy dismantling . . . abutting joints accurately machined and bolted together for dust-tight fit.



3 Completely Lined Crushing Chamber

Heavy, renewable liners . . . sectional for easy plate-at-a-time replacement . . . engineered to offer life-time protection to the frame.



4 Complete Accessibility to Adjustment and Parts

All adjustments external—even with crusher in motion. Rotor easily reached by removing top section. Rings readily reversed or replaced. Liners quickly reached, too, for periodical inspection.

WRITE for Coal Crushing Bulletin

American PULVERIZER COMPANY

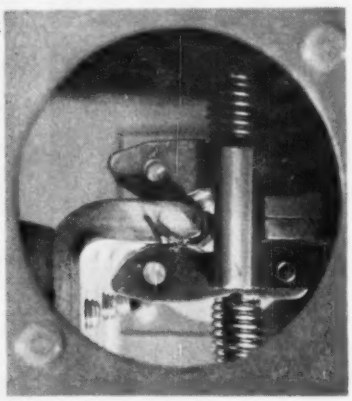
Designers and Manufacturers of Ring Crushers and Pulverizers

1349 MACKLIND AVE. • ST. LOUIS 10, MO.

Equipment news

Begins on page 152

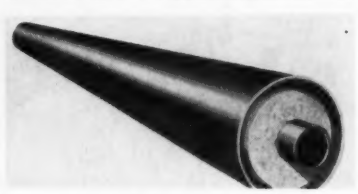
ing or conveying, wherever some moisture can be tolerated. Formula 117 comes in 15- and 55-gal drums.—*Circle Chemical Company, 333 N Michigan Ave, Chicago 1, Ill.*



Visible-break circuit breakers

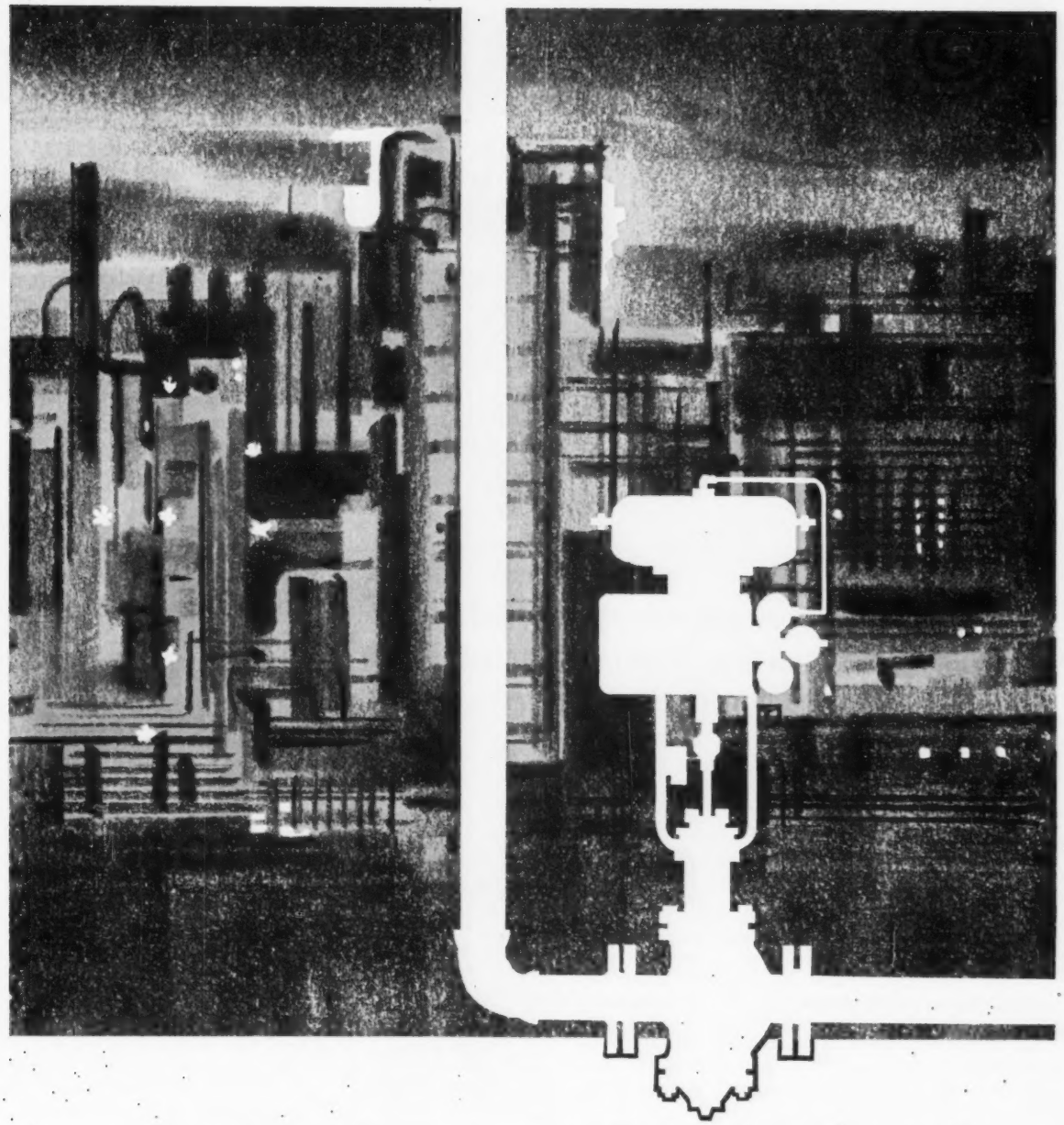
1213 • Visible break provides positive proof that breaker has been disconnected. This is a feature of the individually enclosed models of low-voltage power circuit breakers, designed for industrial plants, power stations. Rated 600 v in 225-, 600- and 1600-amp frame sizes, units offer four features: (1) disconnect contacts can be checked through opening in side of enclosure (2) breaker can be withdrawn to disconnect position without removing front cover (3) access for making cable connections is easy (4) standard lugs can be used for making cable connections.—*I-T-E Circuit Breaker Company, 1900 Hamilton St, Philadelphia 30, Pa.*

For more details on these items, use post cards p 165. Identify your request with item number.



Prefab piping system

1214 • Systems are designed for underground or overhead distribution of steam, hot water, oil, other viscous fluids, process liquids and refrigeration. Complete system is factory prefabricated and shipped direct to job



...almost forgotten...because it does its job so well!

Dependable, year-after-year performance makes a Fisher Diaphragm Motor Valve the preferred control in the power and process industries. The Fisher D.M.V. has features not available on other brands. The extra thick steel casing, the precision finished valve stem, the large capacity and the trouble-free operation—these are just a few of the reasons a Fisher gets the nod when it comes to diaphragm motor valve selection.

If you want to know more about the ultimate in control—the Fisher Diaphragm Motor Valve—write for Bulletin E657A.

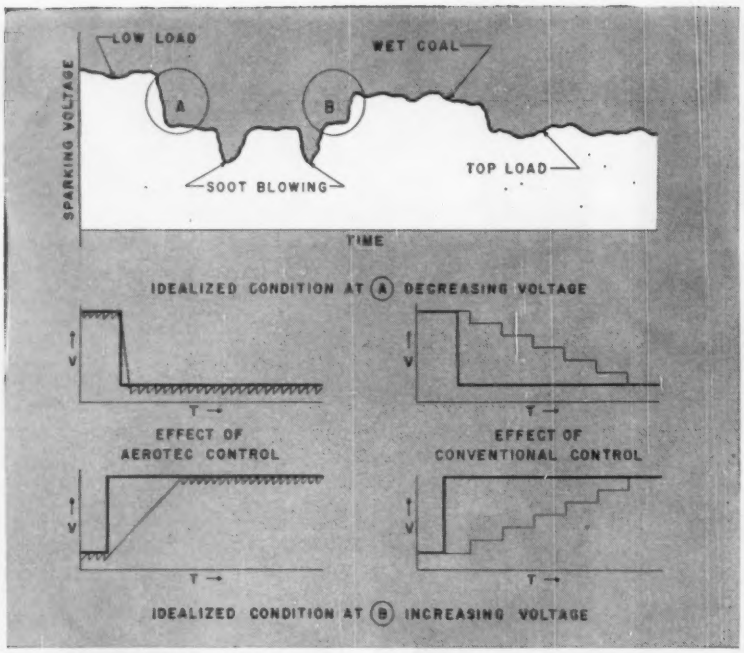
IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England.

FISHER® Controls

SINCE 1880



AEROTEC

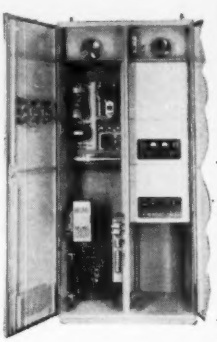
INSTANTANEOUS AUTOMATIC CONTROL MAINTAINS OPTIMUM ELECTRICAL PRECIPITATOR EFFICIENCY

This new automatic system eliminates the undesirable lagging characteristics of conventional spark rate controls. It is based on a voltage proportional to a current signal balanced against a constantly rising reference voltage. This difference, used to control current input to the main transformer, constantly forces an increase in precipitator current.

The diagram illustrates the fluctuation of the sparking voltage as a function of time. At (A) while the voltage suddenly drops, the conventional control samples the sparking rate and drops in incremental steps over a period of time. The Aerotec Controlled Voltage, however, drops almost instantly. The Aerotec control also follows the sparking voltage rapidly as it rises, while again it is seen that conventional control rises in increments, resulting in appreciable lag.

Aerotec pioneered many unique developments in electrical precipitation. Pocket type collecting electrodes retain dust particles more efficiently by providing a static area out of the path of flow. Advances in power supply design produced the electronic, the selenium and the silicon diode rectifier power systems . . . and now, the Aerotec automatic control assures maximum efficiency within safe sparking limits.

For further information on these developments contact our Project Engineers, The Thermix Corporation.



The Aerotec Control Unit is compact and provides easy access to components.

Project Engineers
THE THERMIX CORPORATION
Greenwich, Conn.
(Offices in 38 principal cities)
Canadian Affiliates: T. C. CHOWN, LIMITED, Montreal

Manufacturers
THE AEROTEC CORPORATION
Greenwich, Conn.

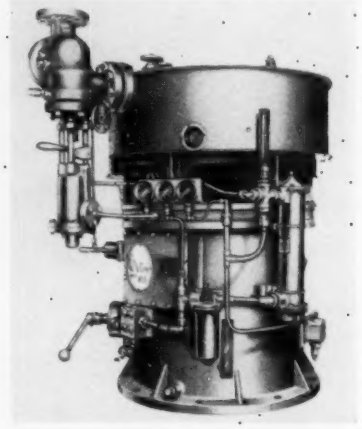
Equipment news

Begins on page 152

site. Units are available for single or multiple insulated pipe systems.—*Portage Insulated Pipe Company, 53 Antles Ave, Barberton, Ohio.*

Snap-on boiler tube sheath

1215 • Stainless-steel sheath for condenser and boiler tubes is designed to deter erosion, prevent material wastage, and extend the service life of original equipment. The shields are available in lengths and sizes to fit most industrial needs, and are made to customer's specs.—*Vince Basnik Co, 2020 Center St., Cleveland 13, Ohio.*



Vertical pump-drive turbine

1216 • Vertical steam turbines in the 100- to 1000-hp range are especially designed for vertical pump drives and similar power-supply applications. Small mounting diameters require minimum installation space, allow greater freedom of location.

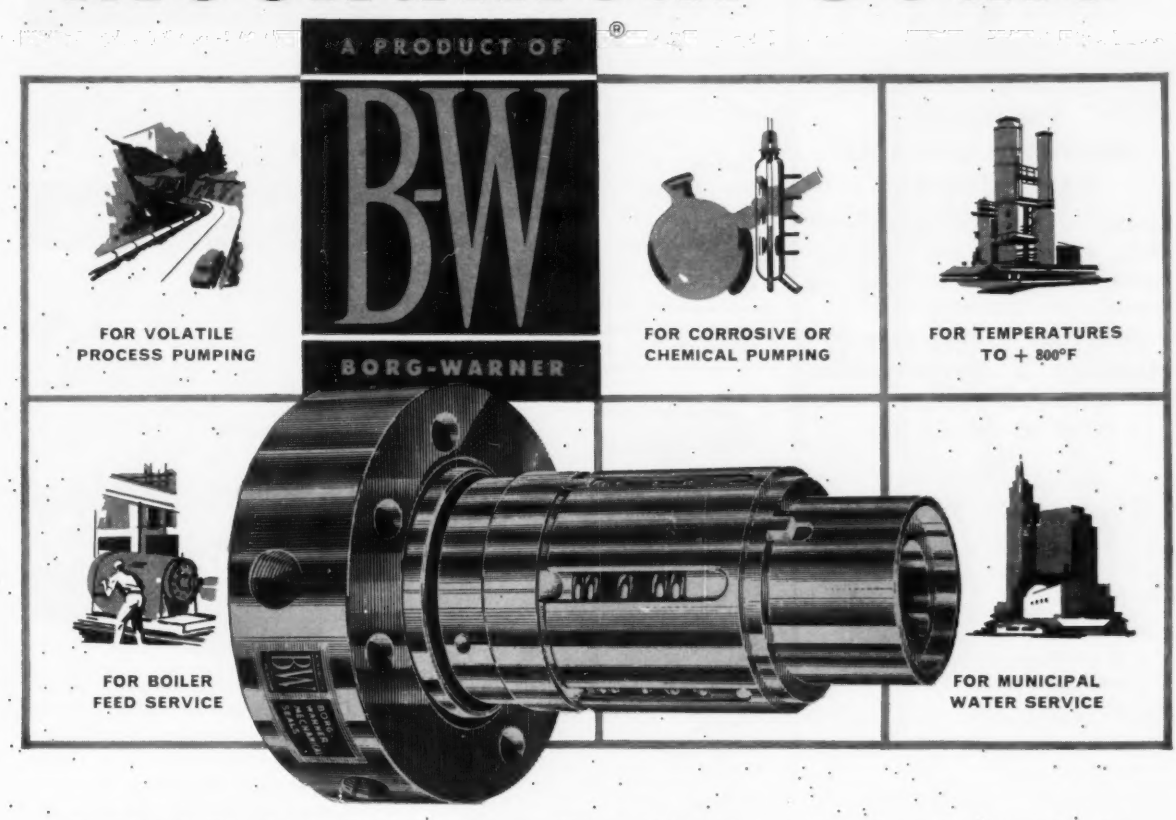
Turbines are capable of speeds up to 8500 rpm, steam pressures to 1250 psig. A construction feature is the horizontally split steel casing with steam inlet and exhaust connections in the upper half.—*The Whiton Machine Company, New London, Conn.*

For more details on these items, use post cards p 165. Identify your request with item number.

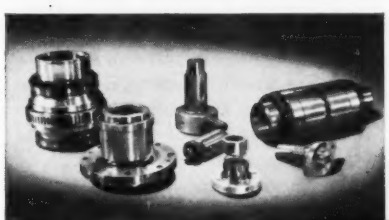
Generator shaft-sealing system

1217 • Shaft-sealing system now provided with medium-capacity generators is said to simplify operation, reduce cost and complexity of installation, and ease inspection; main-

Now...Borg-Warner® Mechanical Seals



Precision shaft seals for all makes and models of centrifugal pumps...and other rotating shaft sealing applications



A PRODUCT OF B-W BORG-WARNER

Because of their wide acceptance and rapid growth, the complete line of mechanical seals—developed and perfected by Byron Jackson—now becomes a separate, industrial division of Borg-Warner.

Borg-Warner Mechanical Seals are now available for almost every make, model and size centrifugal pump... almost every pumping condition... and for other difficult rotating shaft sealing applications.

Even under critical conditions of pressure, volatility, toxicity, corrosion, abrasion and other tough fluid handling jobs, these precision mechanical seals furnish completely reliable stuffingbox performance. They're easy to install and maintain... eliminate expensive downtime and repacking.

This new Borg-Warner Mechanical Seal Division provides larger, more efficient sales, engineering, manufacturing and service facilities. It concentrates an even greater research and development program to create new and improved seals for tomorrow's shaft sealing needs.

Send for the new Borg-Warner Mechanical Seal bulletin—there's no obligation!

Borg-Warner Mechanical Seals

Division of Borg-Warner Corporation

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Condensing, Feedwater Heating, Evaporating, Air Removal and Condensate Cooling Equipment required in any Thermal Power Generating Plant.

CONDENSERS • EVAPORATORS
DEAERATORS • HEAT EXCHANGERS
FEEDWATER HEATERS
STEAM JET AIR EJECTORS

CONSECO SERVICE

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- Condensers
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- Lube Oil Coolers
- Drain Coolers
- Evaporators
- Refrigeration Condensers
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- Heaters and Coolers
- Tube Sheets
- Water Coolers

CONSECO SERVICE is as near as your telephone . . . 24 hours a day . . . 365 days a year including Sundays and holidays . . . from Maine to California. Just call Maintenance Department (see 'phone numbers below).

CONDENSER SERVICE and ENGINEERING CO., INC.

164 Observer Highway, Hoboken, N. J.

N. J. Telephone: OLdfield 9-4425
N.Y.C. Telephone: BArclay 7-0600

Send For Latest Steam Condenser Bulletin. ►

For more details consult the Chemical Engineering Catalog . . pp. 1035-1038

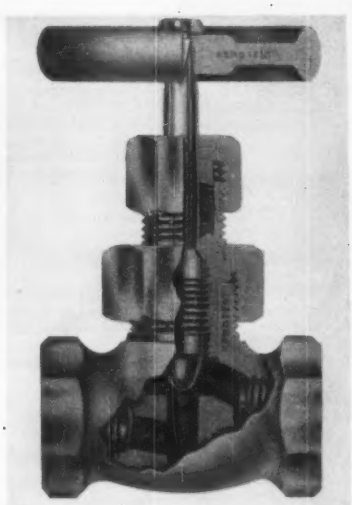
Bulletins on all CONSECO PRODUCTS *sent on request.*

Equipment news

Begins on page 152

tenance, and adjustment. In the new system: (1) standby oil pump is mounted on main oil tank (2) sufficient pressure capacity is provided to seal generator at all hydrogen pressures up to 30 psig without using booster pumps (3) major drain enlargements and pumping runs are mounted directly beneath generator (4) filtering, metering equipment is improved (5) a vapor extractor gives positive venting of trapped portion of bearing drain lines (6) space requirements for auxiliary equipment, number of field welds needed to connect system are reduced.—*General Electric Company, One River Road, Schenectady 5, N. Y.*

For more details on these items, use post cards p 165. Identify your request with item number.



Needle valve for h-p service

1218 • Globe type valve is for throttling, regulating, shut-off. It features a forged carbon steel body, back-seating construction which permits repacking while under pressure, and heat-treated stainless-steel stem operating in a sleeve yoke. Maximum working pressure is 10,000 psi at 70 F, and maximum operating temperature is 750 F.—*Kerotest Manufacturing Company, 2525 Liberty Avenue, Pittsburgh 22, Pa.*

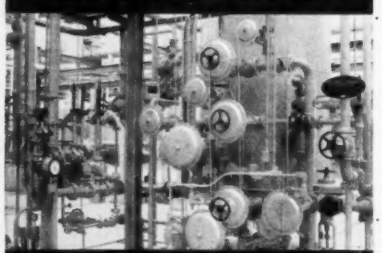
Large condensing units

1219 • Available in five models with ratings from 10 to 30 tons, unit

ILLCO-WAY ionXchange

HOW TO "AUTOMATE"

BOILER FEED WATER



WITH AN ILLCO-WAY "POWER UNIT"

These pictures show an *Automatic* Mixed-Bed De-Ionizer designed for an outdoor installation at a power plant in Louisiana. The high-pressure boilers require feed water of uniform maximum purity — which this ILLCO-WAY "Power Unit" supplies *without attention* other than periodic checks of recording instruments. ILLCO-WAY "Power Units" are shipped *completely assembled*, ready for installation and hook-up.

REMOVES SILICA AND CO_2

The Mixed-Bed IonXchanger, as designed and manufactured by Illinois Water Treatment Company, is often the most economical and most reliable means for treating *any kind* of supply water to obtain the maximum purity required by modern power plants. *See your ILLCO-WAY representative for details on specific applications.*

U.S. PATENTS: 2,771,424 2,605,084

ILLCO-WAY

ILLINOIS WATER TREATMENT CO.
840 Cedar St.
Rockford, Ill.

NEW YORK OFFICE: 141 E. 44th St., New York 17, N.Y.
CANADIAN DIST.: Pumps & Softeners, Ltd., London, Can.

New Edward Instrument Valve *with integral hard-faced seat ends corrosion-erosion problems!*

Used to be, you had to choose between valves of stainless steel—which were difficult to weld into carbon steel pipelines—and valves of carbon steel, which soon corroded and began to leak around the seat. Scientists in the Research Laboratories at Edward Valves, Inc., have been hard at work on this common, costly, irritating problem. And—as usual—they have come up with the solution.

Valve seat now hard-faced with cobalt-chromium-tungsten alloy

This new Edward instrument valve combines a carbon steel body with a cobalt-chromium-tungsten seat face for long, dependable, corrosion-resistant life. *The seat is integral with the body to eliminate leak problems.* Precision machining of the alloy seat—in the same set-up as the body bore—is followed by careful lapping to form drop-tight mated seating faces with 100% bearing surface. The carbon steel body permits easy, efficient welding into carbon steel pipelines. Screwed ends are also available.

Precise flow control

Precise flow control is achieved by tapered needle point stem disk and fine pitch screw threads. This new Rockwell-built Edward instrument valve meets the need for a small, compact stop and variable flow valve for high-pressure, high-temperature service. Rated at 2500 lb. at 850F., the new valve is ideal for all power plant instrumentation. The stainless steel body line will continue in production for applications requiring extreme corrosion resistance.

For further information on the new Edward instrument valve, write for Bulletin 571.

Edward Valves, Inc., 1230 West 145th Street, East Chicago, Indiana. (Subsidiary of Rockwell Manufacturing Company.) Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame St. W., Montreal 1, Quebec.

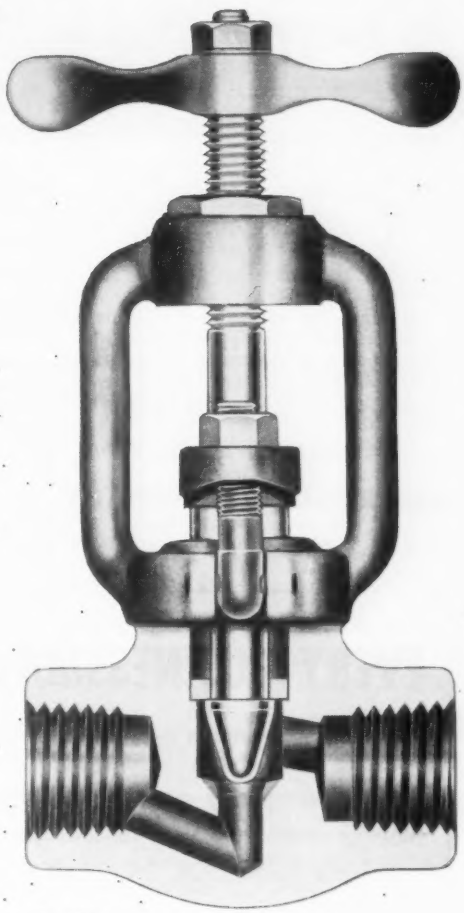
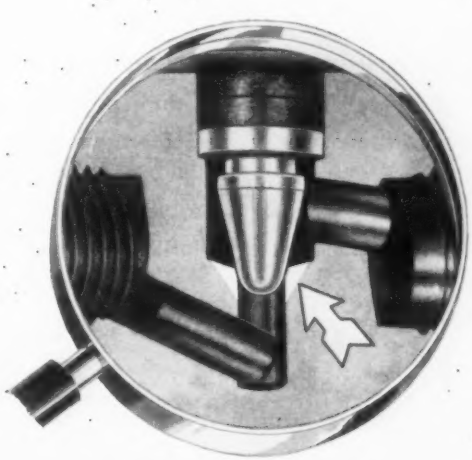


Fig. 952

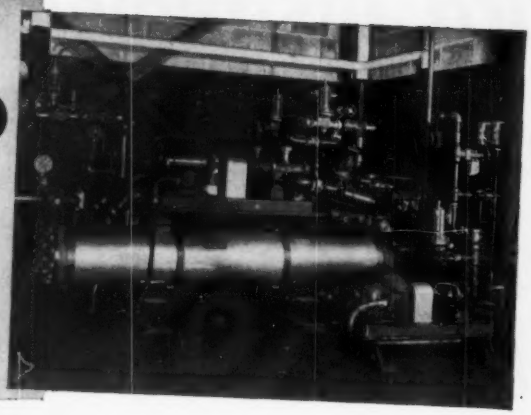


EDWARD STEEL VALVES

another fine product by

ROCKWELL

2 ENCO FUEL OIL UNITS *in this plant*



Here is a typical 2 unit installation of Enco fuel oil pump sets—selected to take care of all the requirements of a building materials manufacturer.

The Large Unit has 2 pumps and 2 heaters, completely automatic and arranged for operation with either heater, or either pump—or both. With one heater and pump the capacity is 11 gpm Bunker C oil at 300 psig pressure, and temperature rise from 90F to 230F.

The Small Unit is for cold starting up—has no heater. The capacity is 3 gpm of No. 2 oil at 300 psig pressure.

All Enco sets are individually designed, each for specific plant conditions—for easy installation, low maintenance and minimum carefree operation.

Complete details including the 10 important features of Enco fuel oil heating and pumping sets are given in Bulletin OB53. Copies gladly sent upon request.

THE ENGINEER COMPANY, 75 West Street, New York 6, N. Y.
In Canada: Rock Utilities Ltd., 80 Jean Talon St. W., Montreal, P. Q.
Palser Enterprises, 378 York St., London, Ontario EC-907

EVERY BUSINESSMAN KNOWS . . .

that money wasted is money we can never recover.

And yet every day many dollars and man hours are lost in mailing rooms and post offices across the land—lost because somebody forgot (OR DIDN'T BOTHER) to include a Postal Zone Number.

Have you ANY COMPLAINTS? . . . postal service? late delivery? lost copies? mail gone astray?

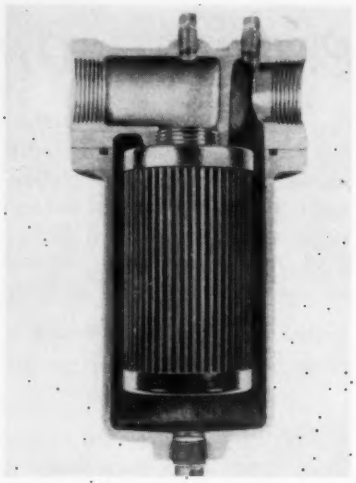
Maybe we don't have your complete address. A complete address includes a Postal Zone Number.

POWER • 330 West 42nd Street
New York 36, N.Y.

Equipment news

Begins on page 152

is a remote air-cooled condenser having compressor, receiver, electrical controls and other refrigeration accessories mounted within its casing. Compressors can be single or dual; dual compressors have separate refrigeration circuits.—*Dunham-Bush, Inc, West Hartford, Conn.*

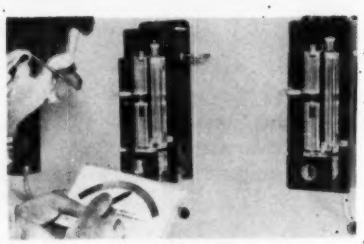


Line type hydraulic filter

1220 • Designed for installation on suction or return lines, filters come in 10, 20, 30, 50 and 75 gpm sizes, with Monel wire cloth mesh sizes from 30 to 100. All units are available without bypass valve.

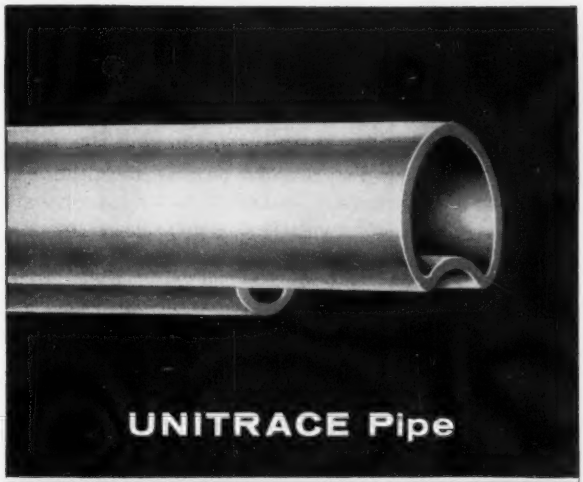
Ample filtering area provides dependable protection on hydraulic and other l-p liquid-circulating systems, according to manufacturer. Vacuum or pressure gage can be added. Units can be disassembled for cleaning.—*Marvel Engineering Co, 7227 N Hamlin Ave, Chicago 45, Ill.*

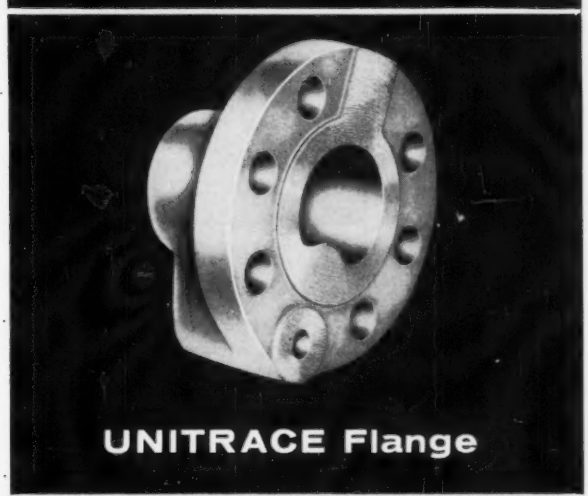
For more details on these items, use post cards p 165. Identify your request with item number.



Boiler-water analyzer

1221 • Chemical analyzer is said to make colorimetric boiler-water analy-





Only **ALCOA** offers a complete new **UNITRACE** system

to cut costs and raise efficiency of steam-traced piping

Users of steam-traced pipe have found that valuable savings in cost plus greatly improved efficiency are automatic when they use ALCOA® UNITRACE. It provides steam and product passages extruded in a single unit of light, strong, corrosion-resistant aluminum alloy... completely eliminating the need for costly external steam jackets or inefficient tracer tubes. Now a new flange and trace cap provide fittings and connections designed for UNITRACE which are compatible with conventional piping. You can now design completely integrated UNITRACE piping systems and get all these benefits:

Low heat loss... high internal heat transfer
The recently introduced *round* configuration of UNITRACE makes possible most efficient internal heat transfer with minimum external radiation loss.

Easy, economical joints and connections
The special UNITRACE Flange mates with all 150-lb ASA flanged connections, permits use of standard flanged valves or other flanged connections. And the new UNITRACE Trace Cap permits quick, easy assembly of cross or tee connections.

Uses standard, preformed pipe insulation
The efficiency of UNITRACE often makes insulation unnecessary. When it *is* needed, standard preformed insulation can be used. UNITRACE saves extra dollars by employing smaller diameter insulation than conventional systems.

Excellent corrosion resistance
Thanks to the natural corrosion resistance of aluminum, UNITRACE is ideal for handling naval stores, molten sulfur, ammonium nitrate solutions, glacial acetic acid, fatty acids, tar, pitch, wax, urea, and similar products requiring heated transfer lines.

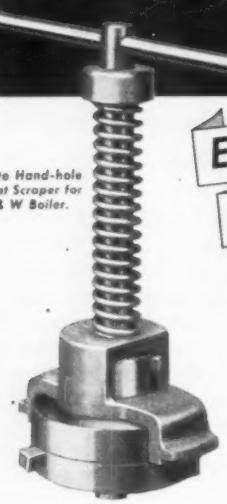
ALCOA UNITRACE and matching fittings are available in four standard pipe OD's: 1½", 2", 3" and 4". Get complete details on how you can use them to raise efficiency and lower cost on your own heated transfer lines. Call your nearest Alcoa sales office or write Aluminum Company of America, 888-M Alcoa Building, Pittsburgh 19, Pa.

Write for this FREE BOOKLET
This fully illustrated booklet contains complete engineering, specification and fabrication data on ALCOA UNITRACE. Write for your free copy!

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

ALCOA THEATRE
Fine Entertainment
ALTERNATE MONDAY EVENINGS

ROTO Hand-hole Seat Scraper



Roto Hand-hole Seat Scraper for B & W Boiler.

Eliminates tedious labor

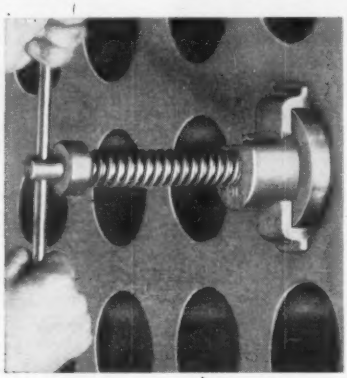
Assures clean, tight fit

Roto Hand-hole Seat Scraper makes short work of cleaning dirty hand-hole seats. This simple, hand-operated tool has adjustable, spring-mounted retractable knives. A few turns to the right remove foreign matter without cutting the metal. A half turn to the left releases the tool, and the job is done. Customers say that the Roto Seat Scraper does the job up to 12 times faster than by any other method. Try one and you'll wonder how you ever got along without it. *Send for details.*

Now available

for most hand-hole shapes and sizes

Standard Roto Seat Scrapers are available for the following equipment. Special types made to order.



Illustrating ease of operation of Roto Hand-hole Seat Scraper.

Type of Boiler	Opening	Tube Size
Babcock & Wilcox # 4	Round	2"
" " " #41	Oval	2"
" " " #70	Round	3"
" " " #48	Oval	3½"
" " " #40	Oval	3¼"
" " " #24	Oval	4"
" " "	Oblong	4"
Bros	Round	3¼"
Casey Hedges	Oval	3½"
" "	Oval	4"
Combustion Eng'rg	Round	3"
" "	Oval	3"
Edgemoor	Oval	4"
Erie City	Ellip	2½"
" "	Oblong	3¼"
" "	Ellip	3¼"
" "	Pear	4"
Foster Wheeler	Oblong	2½"
" "	Oblong	3"
" "	Ellip	4"
Geary	Oblong	4"

Type of Boiler	Opening	Tube Size
Heine	Round	3½"
"	Oval	3½"
International Boiler 2	Oblong	3"
Keeler	Round	3½"
"	Round	4"
"	Diamond	3½"
"	Diamond	4"
Lasker	Oblong	
Murray	Oval	3½"
"	Oblong	4"
Oil City	Oval	3½"
" "	Oblong	4"
Riley Stoker	Ellip	3¼"
Springfield	Ellip	3¼"
Union Iron Works	Pear	4"
Henry Vogt	Ellip	3¼"
" "	Oval	4"
Walsh & Weidner	Oval	4"
Wickes	Ellip	2½"
"	Ellip	3¼"
" "	Pear	4"
"	Round	4"

ELLIOTT COMPANY – ROTO PLANT

Tube Cleaner Specialists Since 1910

153 Sussex Avenue, Newark, N. J.

Equipment news

Begins on page 152

sis simple and inexpensive. Unit has no moving parts, needs no electric or pneumatic power to operate. Accuracy is said to be adequate for normal water testing—2 to 5% of reading. An untrained operator can make spot checks, by visually comparing gradations on a standard color chart with sample in instrument's optical cell.—*Florida Instrument Co, 1300 E Mermaid Lane, Philadelphia 18, Pa.*

For more details on these items, use post cards p 165. Identify your request with item number.

H-t cable jacket

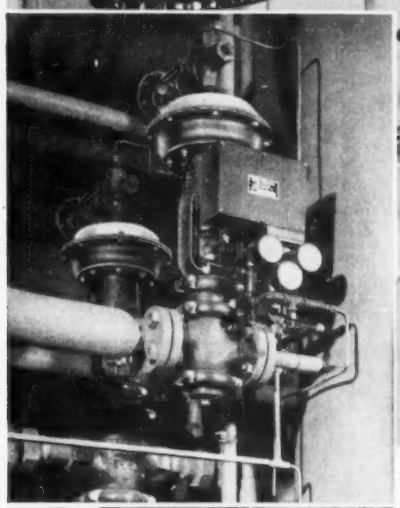
1222 • Easily applied cable jacket will withstand 2000 F continuous operating temperature and 3000 F for brief periods, according to maker. Made of aluminized reflective asbestos fiber; jacket is closed by a plastic or metal zipper track stitched to the fiber with h-t Teflon thread. An external flap protects track and keeps assembly looking neat.

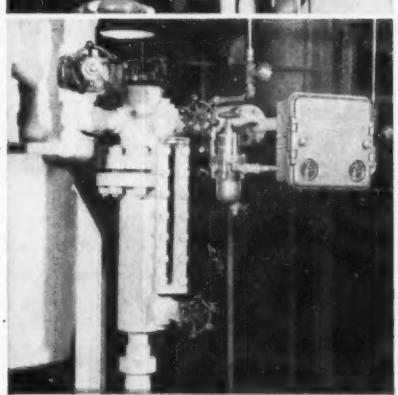
Jacket comes in ID's from ⅜ in. up. Standard put-ups are 25, 50 and 300 ft.—*The Zippertubing Company, 752 S San Pedro St, Los Angeles 14, Calif.*

Explosionproof photorelay

1223 • Photorelay and projector meet requirements for machine, production or process applications in tough conditions. They are not affected by wetness, dirt, shock, vibration or temperature extremes, manufacturer states. There is no internal heating and no warmup delay prior to operation.

Operation is from 100 to 130 v at 25 to 60 cycles. Relay is controlled by eight ft-c of light from a light projector in an identical explosionproof housing. The projector and photorelay can be placed up to 20 ft apart.—*Photobell Company, 43 Vesey St, New York 7, N. Y.*





SUPER BS&B 70

Power Plant With A Forward Look!

Playing an important role in the operation of this modern, efficient power plant located at Escanaba, Michigan, are seventeen BS&B Super 70 Diaphragm Control Valves with clamp ring-float ring body closures. The plant, operated by the Upper Peninsula Power Company, is also equipped with BS&B Liquid level controllers, pilots and air regulators.

Super 70's are available for power plant applications in a complete range of sizes with either clamp ring-float ring or flanged-gasketed body closures.

Next time you have a new station "on the boards", specify BS&B Controls right down the line. They're dependable, efficient, and cut down maintenance costs. You'll get application engineering assistance, too!

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Controls Division, Dept. 4-Q12
7500 East 12th Street Kansas City 26, Missouri

With industry everywhere

the No. 1 choice is the V-belt with concave sides

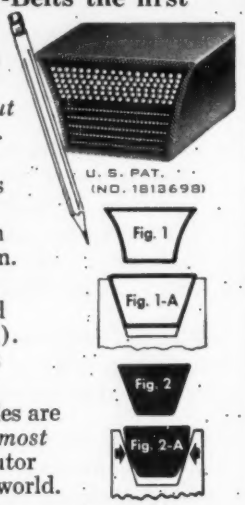
It is easy to see why concave sides insure far longer belt life... and make Gates V-Belts the first choice of industry everywhere.

Just *make this simple test:* bend a Gates V-Belt as if it were going around a sheave. Feel how the concave sides (Fig. 1) *fill out* ... become perfectly straight (Fig. 1-A).

Note how this belt thus makes full contact with the sides of a sheave ... grips the sheave evenly, distributing wear uniformly across the sides of the belt. Uniform wear lengthens belt life — keeps costs down.

With a straight-sided belt (Fig. 2) the sides *bulge out* when the belt is bent, and wear is concentrated on the bulge (Fig. 2-A). Uneven wear shortens belt life — increases belt costs.

Because Gates V-Belts with concave sides are so universally preferred, they are also the *most widely available.* There are Gates Distributor stocks in industrial centers throughout the world.



The Gates Rubber Company, Denver, Colorado

Gates *World's Largest Maker of V-Belts* TPA 351

Gates VULCO ROPE Drives

Technical briefs

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With a 6-pole rotor output, frequency is 360 cps at a pump speed of 3600 rpm. Wave shape is rather saw-toothed than sinusoidal. Voltage output vs rpm is linear, but it's better to use frequency as an indication rather than voltage. Many different output devices can be used with the indicator, with amplification optional; it can drive a magnetic oscillograph directly, be hooked to an EPUT counter, or teamed with a frequency transducer, depending on accuracy needed. *ISA paper, No. PNW-7-58*

Continuous water monitor for radioactive waste. *By F E Gillespie and R E Zedler, Oak Ridge National Laboratory*

A water monitor that works continuously instead of on a batch basis has been in operation at Oak Ridge National Laboratory since April, 1958. The monitor controls low-level large-volume process water from the lab.

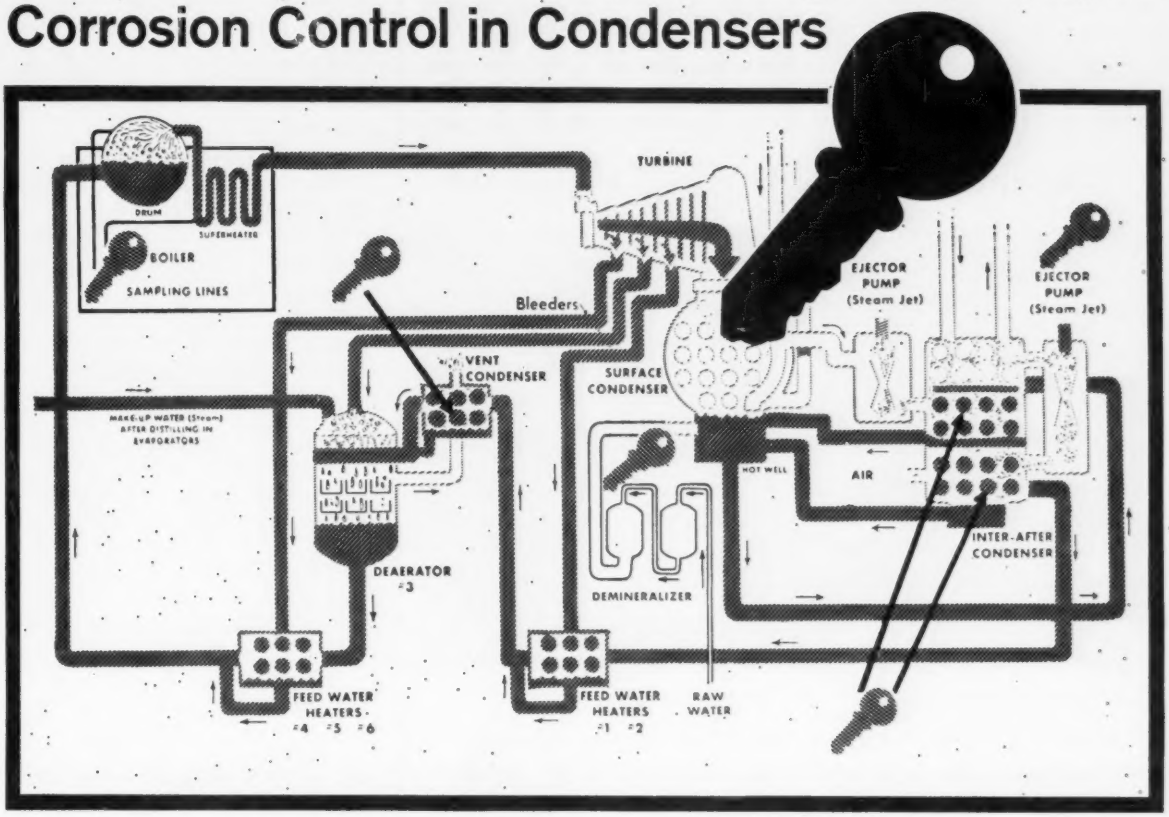
Parts for the monitor were selected for low-cost disposal. Main container is an inverted polyethylene bottle with the bottom cut off (over-all length about 12 in.) Five halogen-filled thin-walled Geiger tubes slipped inside celluloid centrifuge tubes (to protect the tubes from contamination) are placed around the inside of the bottle. Sampling water flows up through the bottle neck around a stainless-steel discharge tube. A second, smaller polyethylene bottle, also with the bottom removed, acts as a drain and is placed so its open bottom is slightly below the bottom of the larger bottle. The neck of the smaller container fits into the top of the discharge tube, which runs on down to the main water pipe from which the sample water is drawn. The entire assembly is covered by a lead shield and fixed to a concrete pad over the main pipe.

Paper presents drawings of the system and a calibration method. Further drawings and photos can be obtained from the AEC Technical Information Service.

System allows continuous contamination control, remote monitoring and checking of detector operation, elimination of a building to house

Directions for ordering papers on page 206

Now... Proved by over 3 Years' Service... Carpenter Stainless Steel Tubing is the Key to Corrosion Control in Condensers



Carpenter long ago proved its superiority in most power plant applications. But now, surface condensers can be added to the list, after careful in-service tests made over a period of more than 3 years at a large Eastern utility plant.

Carpenter tubing serves better in any highly acidic water and provides excellent heat transfer rates (above published rates) at high velocities and water temperatures.

For more information on the Master Keys to better service and economy from the "House of Corrosion Control," contact our nearest office or write direct to The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

your master key to cost-saving corrosion control

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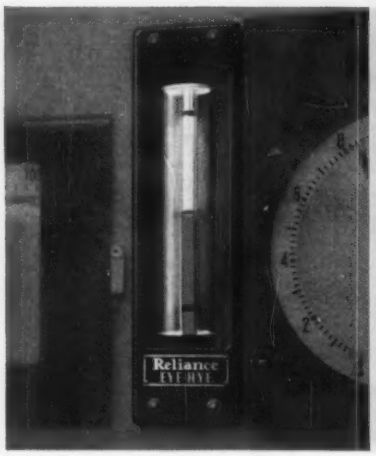
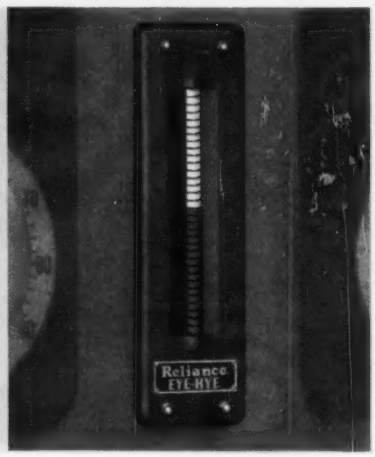
available through representatives . . . coast to coast

Safe, sure check on boiler water levels with wide-vision EYE-HYE

The remote gage with liquid indication



EYE-HYE for pressures up to 600 psi



EYE-HYE for pressures up to 3000 psi

Put your boiler water level supervision on a plane with other power plant control facilities — read levels at your control station with Reliance EYE-HYE.

The dependable accuracy of this popular remote reading indicator eliminates "boiler-climbing"; its bright green liquid-column image stands out — mistake-proof. And EYE-HYE's improved design provides visibility over a wide arc — lower pressure models up to 90°; new higher pressure models, to 180°.

Simple manometric design, with no mechanical parts and no adjustments on location. Available with economical special attachment to actuate supplementary alarms . . . Write for catalog information on EYE-HYE for *your* boiler pressure.

The UNITEMP, complete temperature equalizing unit furnished with each EYE-HYE

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The Reliance Gauge Column Company

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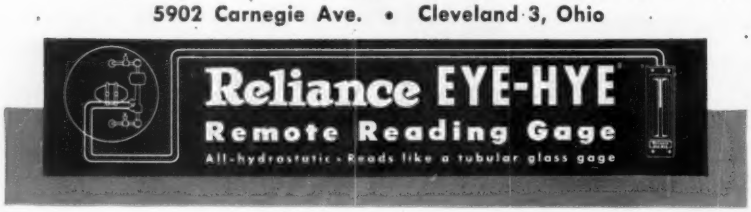

Technical briefs

Begins on page 148

the monitor. Although this system is designed for large-scale installation, authors hope parts of the design can be altered for small laboratory application. *ISA paper, No. PNW-6-58*

Power-plant corrosion-control efficiency monitored by a continuous dissolved-oxygen analyzer. *By R C Tucker, Niagara Mohawk Power Corp and T J Kehoe, Beckman Instruments, Inc*

Reliable analysis of O_2 concentrations in power plants is usually extremely difficult. Manual chemical analysis is accurate but time consuming. It requires a high degree of technical precision and is only a spot check of conditions at the time samples are taken. Automatic continuous testing and recording can overcome these problems.

A key to corrosion effect due to oxygen can be obtained by determining oxygen losses from point to point in the cycle (this is especially true when the accuracy of the instrument is established). The method indicates how well oxygen-removal equipment is working (such as the effect of opening or throttling the condenser steam jets).

The paper also discusses several of the common causes of air leaks into the water-steam cycle. *ISA paper, No. PAT. 2-58*

Accurate control of a small liquid flow. *By L Griffith, Celanese Corporation of America*

Getting accurate control of small flows isn't always simple, especially if a flow ratio or cascade system is included. To ease this problem we designed our own instrument, and now control 0-3 gpm with an error of about 1%.

Measuring container is an H tube. Flow enters at right angles to the bottom of the first leg, moves up the tube, overflows through the middle bar of the H and down into the second leg. Flow in is controlled by a solenoid, flow out by a pneumatic control valve. A combined measuring-transmitting instrument fits over the top of the H legs and measures electrical conductance of fluid in both

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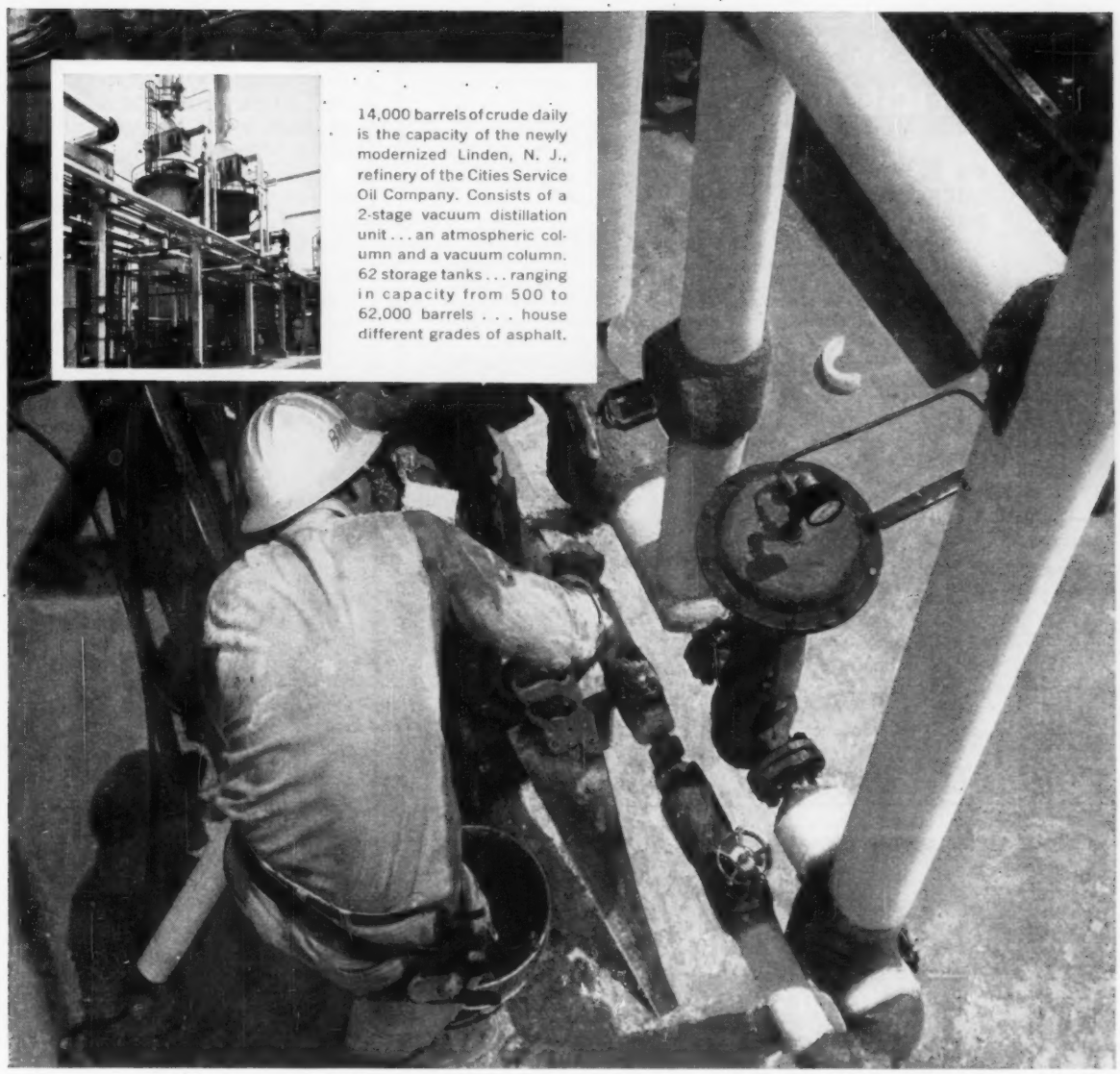

14,000 barrels of crude daily is the capacity of the newly modernized Linden, N. J., refinery of the Cities Service Oil Company. Consists of a 2-stage vacuum distillation unit . . . an atmospheric column and a vacuum column. 62 storage tanks . . . ranging in capacity from 500 to 62,000 barrels . . . house different grades of asphalt.

138,000 feet of "K&M" KaytherM Block Insulation and 56,000 feet of "K&M" KaytherM Pipe Insulation handle a range of operating temperatures from 90°F. to 700°F.

"K&M" KAYTHERM KEEPS A RIVER OF ASPHALT FLOWING AT NEW CITIES SERVICE REFINERY

You've got to keep asphalt hot in order to keep it moving. And, move it must : . . from distillation unit to storage tank . . . It's outdoor travel . . . where the insulation must be strong and tough enough to withstand the ravages of weather.

That's why you'll find "K&M" KaytherM Pipe and Block Insulation on the job at this modern, new refinery. It's weather-resistant and chemically stable . . . doesn't disintegrate or lose efficiency. Remains highly efficient to 1350°F.

Strong, lightweight, and easy to work, "K&M" KaytherM reduces installation and maintenance costs. You can use it indoors or outdoors for every use.

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Flanders Airpure Filters solve the most critical air filtration problems for all atmospheric conditions. Flanders now offers to industry the same research, design, production and testing capabilities utilized in the high-efficiency systems developed for the Atomic Energy Commission.
Flanders Airpure Filters insure against product rejection due to sub-micron dust particles.

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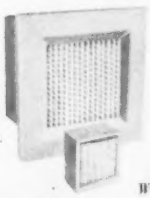

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For AIRPURE efficiency in very high temperatures (up to 2300°F.) Flanders has developed a filter made entirely of ceramic materials. Abrupt temperature changes have no effect on this filter.

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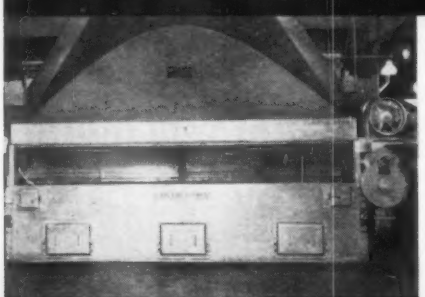
ANOTHER Large State University, the UNIVERSITY of MISSOURI, has included two large LACLEDE CHAIN GRATE STOKERS in its Expansion Program



One of two identical Laclede Chain Grate Stokers at University of Missouri Power Plant

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FOUNDED IN 1904

Each 266 sq. ft. stoker-fired steam generator is designed to produce 75,000 PPH continuously with peaks of 82,500 PPH.

An efficiency test using the input-output method which accounts for all losses, was conducted by Burns and Roe, Inc., Consulting Engineers of New York City. See how the test results exceeded the guarantees.

	GUARANTEE	TEST RESULTS
CO_2 leaving economizer	13.7%	13.7%
Combustible loss	1.2%	0.9%
Overall efficiency	83.0%	86.3%

For most efficient, economical operation use Laclede Chain Grate Stokers.

Technical briefs

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legs. It uses comparative values, gotten from probes inserted in the H legs, to trigger solenoid open or shut.

When both legs contain fluid up to the middle bar the solenoid shuts and inert gas entering the H above the middle bar of the first leg pushes fluid in the second leg out past the control valve. After liquid in second leg drops so much—a value you can adjust—the solenoid opens, admitting fluid until the legs are full up to the middle bar again. Solenoid then shuts and cycle repeats.

Put simply, liquid enters in batches and leaves in a controlled continuous flow. Frequency of cycle is adjustable from once every 4 to 400 minutes. Measured hourly, error is less than 1%; from cycle to cycle, error is slightly more.

Paper gives full details of theory and operation of transmitter and controller with accompanying diagrams, sketches. *ISA paper, No. PWC-3-58*

Bearings and lube

Performance of generator thrust bearings at Hoover power plant. *By F B Looper, Dept of Water and Power, City of Los Angeles*

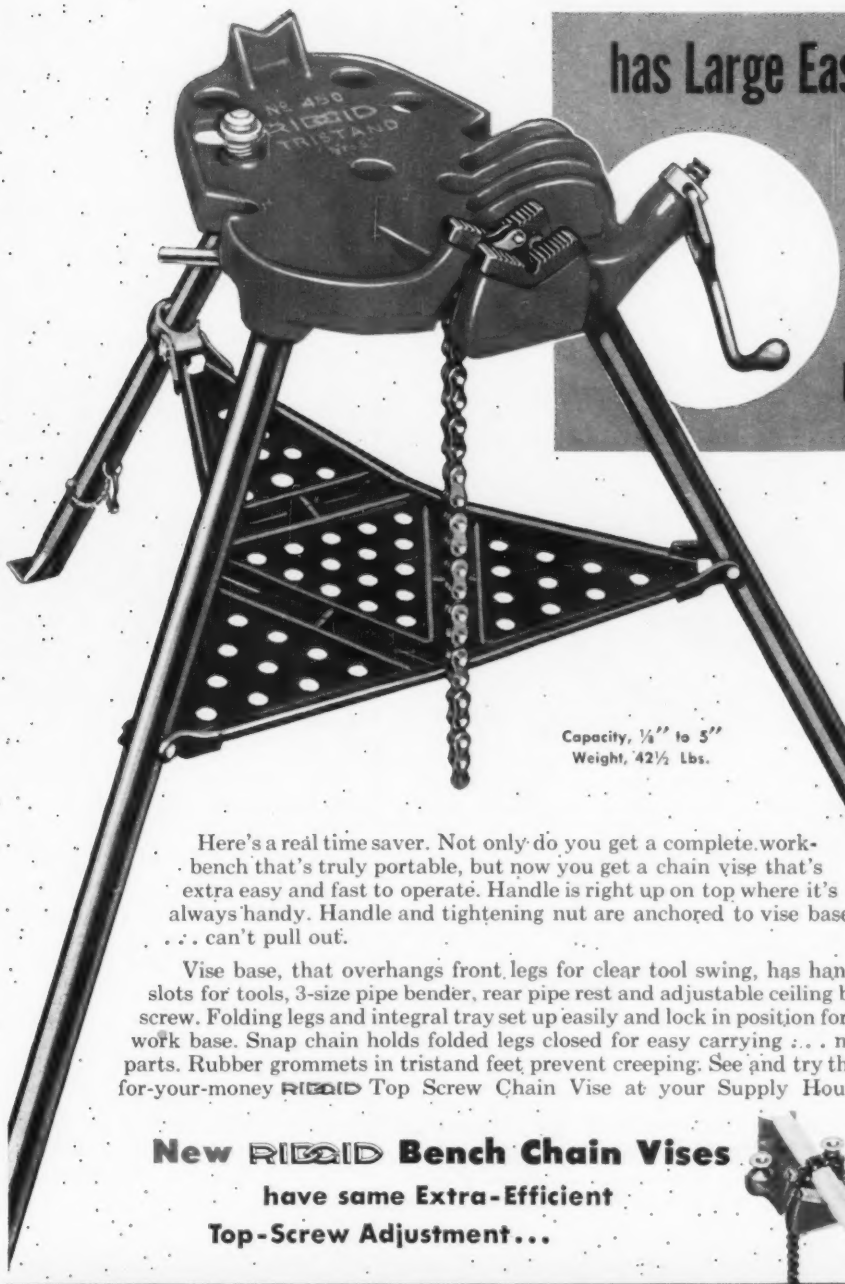
The Los Angeles Dept of Water and Power, as agent for the federal government, operates and maintains 12 main generating units at Hoover power plant. The units were installed during the period of 1936-1952. Each of three major thrust-bearing manufacturers furnished the bearings for four generators. A combined operating record of 185 years of unit service and 17,933 unit starts had been established by January 1, 1958. During that period, 16 thrust-bearing failures occurred. The causes of two were clearly identified. They were not due to any defect or weakness in the bearings themselves. Causes of the other 14 failures were not unanimously decided.

Several changes in bearing design or material have been made since the original installation, some by the manufacturer and some by the department. Six grades or structures of babbitt have been used. The author has grouped the bearings into seven types to indicate design or operating

Directions for ordering papers on page 206

no more knuckle-busting . . .

New RIDGID No. 450 Portable Tristand Chain Vise



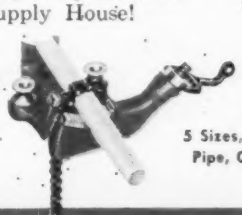
has Large Easy-to-Operate Top Screw Handle right up on top

Capacity, ⅛" to 5"
Weight, 42½ Lbs.

Here's a real time saver. Not only do you get a complete work-bench that's truly portable, but now you get a chain vise that's extra easy and fast to operate. Handle is right up on top where it's always handy. Handle and tightening nut are anchored to vise base . . . can't pull out.

Vise base, that overhangs front legs for clear tool swing, has hanger slots for tools, 3-size pipe bender, rear pipe rest and adjustable ceiling brace screw. Folding legs and integral tray set up easily and lock in position for rigid work base. Snap chain holds folded legs closed for easy carrying . . . no loose parts. Rubber grommets in tristand feet prevent creeping. See and try this more-for-your-money RIDGID Top Screw Chain Vise at your Supply House!

New RIDGID Bench Chain Vises have same Extra-Efficient Top-Screw Adjustment...



5 Sizes, for ⅛" to 8" Pipe, Conduit or Rod

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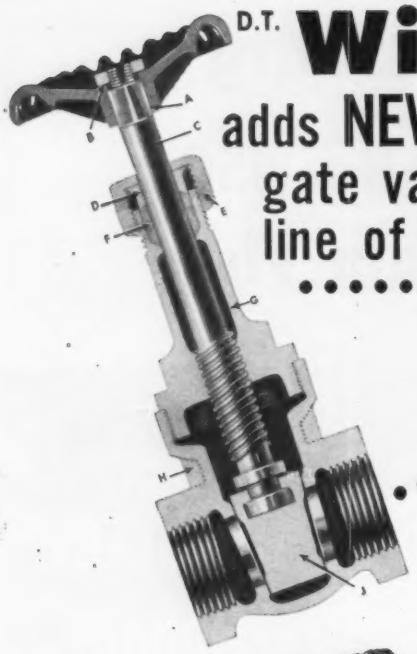
adds NEW SOLID DISC gate valves to the line of Quality Valves



BRONZE FED-STAN® GATE VALVES—The new Bronze Fed-Stan Gate Valves are of the rising stem type and built expressly for steam, water, oil or gas service. These new valves feature bronze taper wedge solid disc and integral seat, screwed bonnet and inside screw rising stem. Like all Williams valves, they have been designed to withstand distortion, pipe and pressure strains. Screw end valves are available in 125 lb. (Fig. 1253) and 150 lb. (Fig. 1254) W.S.P. The valves are built to Federal standards as the Fed-Stan trademark would indicate.

A Hand Wheel
B Wheel Nut
C Bronze Stem
D Gland
E Bronze Packing Nut
F Asbestos Packing
G Bronze Bonnet
H Bronze Body
J Solid Disc

BRONZE UNION BONNET GATE VALVES—Another valve of the rising stem type. All Williams gate valves, when open, present a full way, unobstructed passage through the body, fully equal to the area of the connecting pipes.

In addition to all the benefits of valves of solid disc design, this new one-piece wedge assures necessary flexibility and perfect seating.

Screw end valves are available in 200 lb. (Fig. 129) and 300 lb. (Fig. 976) W.S.P.

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the valves with a reputation built on quality and performance.

Detroit Controls Division of American-Standard, 5900 Trumbull Ave., Detroit 8, Mich.

AMERICAN-Standard
DETROIT CONTROLS DIVISION

Technical briefs

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differences. Altogether, 13 different combinations of babbitt and bearing type have been used; there has also been a considerable range of runner structure and surface finish.

Paper presents a statistical survey of how these different combinations have performed. *AIEE paper, No. 58-769*

Electricity

System control aided by governor transducer. *By R D Nevison, Hydro-Electric Power Commission of Ontario*

A new means for regulating the output of hydroelectric generators by continuous-type electric control signals has recently been developed and tested. It consists of an electrohydraulic servo connected to the governor speed-adjusting mechanism through a lever system, and a magnetic amplifier that amplifies the control signal and feeds it to the servo. The whole assembly is called a governor load-control auxiliary. The electrohydraulic servo is called a speed-setting transducer.

Tests show that substantial improvement in system load-frequency regulation can be obtained through use of this new means of control.

Paper describes the governor load-control auxiliary and tests made with the control auxiliary in a load-frequency control system. *AIEE paper, No. 58-847*

Electric power production and marketing activities of the Department of the Interior. *By K J Plucknett, U.S. Dept of the Interior*

The Congress of the United States has, over a period of 30 or more years, authorized the construction and operation of many multiple-purpose dams and reservoirs. Hydroelectric-power generating facilities have been included at a number of these dams, developing a valuable energy resource. Generally, the availability of hydroelectric power from these projects has assisted in improving the economy of an area.

Dept of the Interior water and power agencies have marketed much of the hydroelectric power generated

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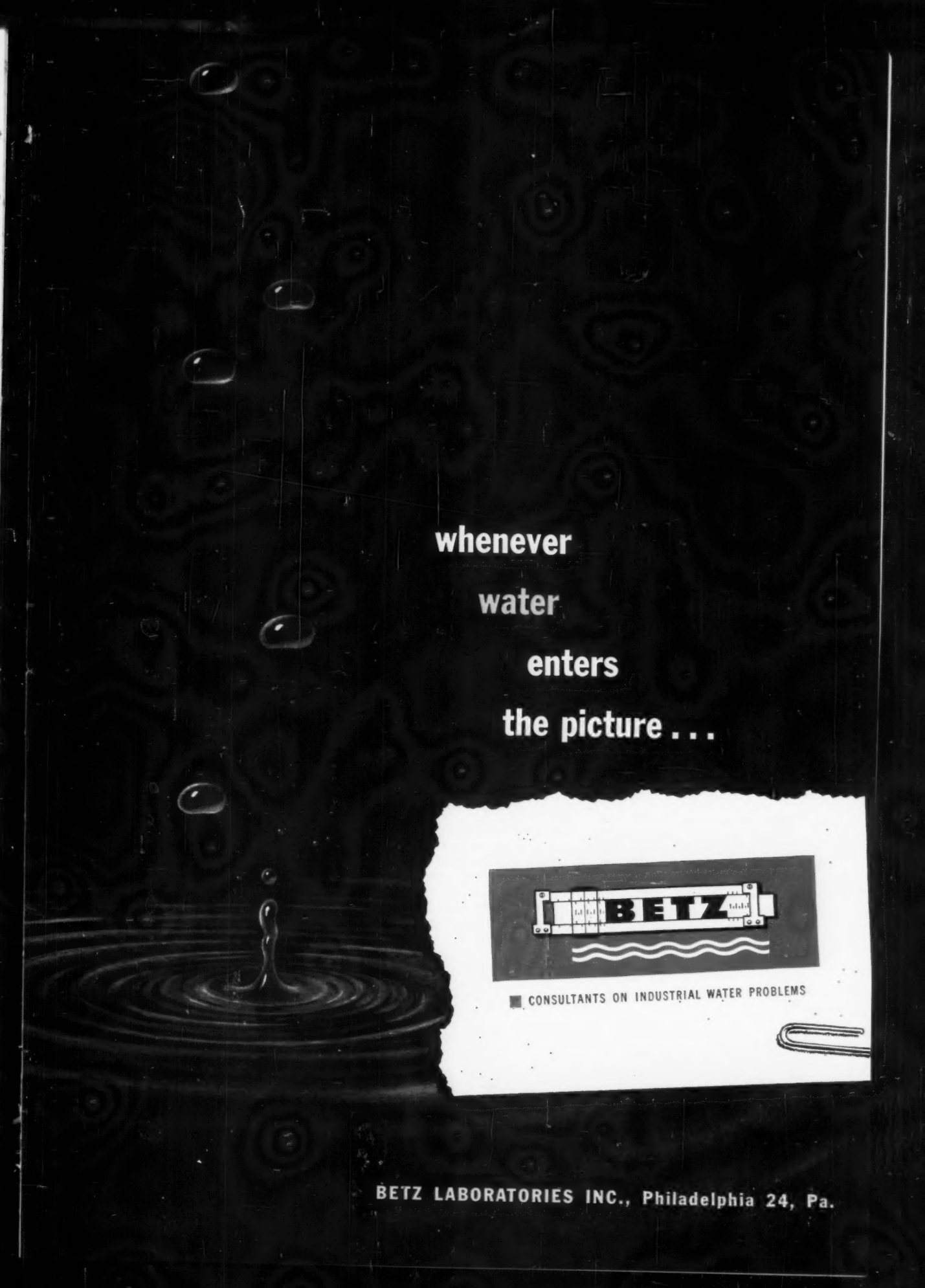
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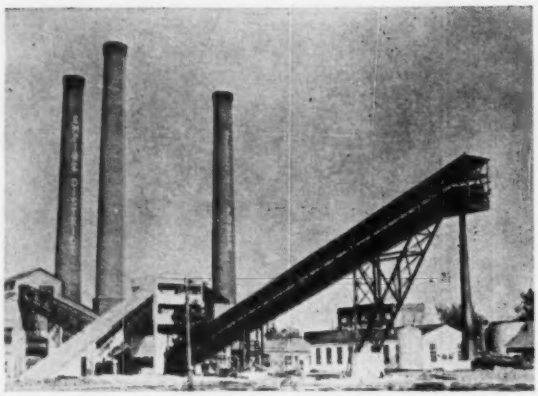
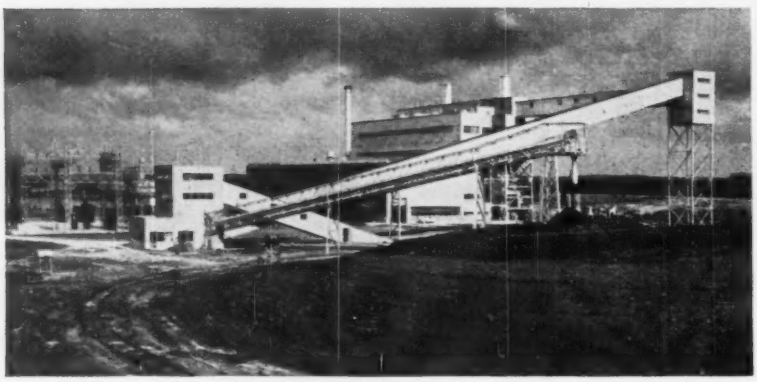


McNally Pittsburg developed this 250 ton per hour system for the EMPIRE DISTRICT POWER & LIGHT CO.



McNally Pittsburg assisted in developing this 300 ton per hour system for the KANSAS POWER & LIGHT CO.

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Are you paying "extra fare" luxury rates for that last ride your coal must take from the truck, car, or barge, to your bunkers?

Why pay more? Why risk breakdowns, when you can *save* extra "profits" and be sure of year-round efficiency.

McNALLY PITTSBURG Systems automatically handle more coal per dollar—minimum maintenance costs.

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Company_____

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Technical briefs

Begins on page 148

at these projects by conventional procedures, using federally constructed and operated transmission systems. In addition, a substantial amount of the power is marketed by unique contractual arrangements, providing for the exchange and wheeling and firming of power to be delivered to customers of the government. These marketing arrangements have been developed to meet requirements of law and the local conditions prevailing in the operating areas of the four agencies (Bonneville Power Administration, Bureau of Reclamation, Southeastern Power Administration, Southwestern Power Administration), to obtain the most widespread distribution of the benefits derived from the power produced. *AIEE paper, No. CP-58-493*

Factors to be considered in selecting a load-frequency control system. *By W C Van Dyke, Niagara Mohawk Power Corp*

The well-established principle of tie-line bias control, supplemented by incremental load distribution among regulating units for optimum economy, provides a satisfactory solution to the system load-control problem on the interconnections existing today. Careful consideration is necessary in selecting the hardware to perform these functions, to obtain high-speed operation which is still stable and trouble-free and compatible with the generating units to be controlled.

Paper discusses the Northeast Interconnection, goes on to describe control-system requirements, considerations in the application of load control to steam-generating stations. *AIEE paper, No. CP-58-931*

TO OBTAIN COMPLETE TEXT

Material for these abstracts comes from the following sources. Order paper from source, not POWER.

World Power Conference. (WPC), order from Engineers Joint Council, 29 W 39th St, New York 18, N. Y.

Instrument Society of America (ISA), 313 Sixth Ave, Pittsburgh 22, Pa.

American Institute of Electrical Engineers (AIEE), 33 W 39th St, New York 18, N. Y.

Remove Condensate and Air without STEAM LOSS with

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A complete line of Low, Medium and High Pressure Thermostatic Traps for service with radiation, dryers, sterilizers, mangles, cookers and similar uses. ***Renewable thermostats and seats are important constructional features contributing to long life and low cost service.*** **Medium and High Pressure Traps have stainless steel pins and renewable seats.**

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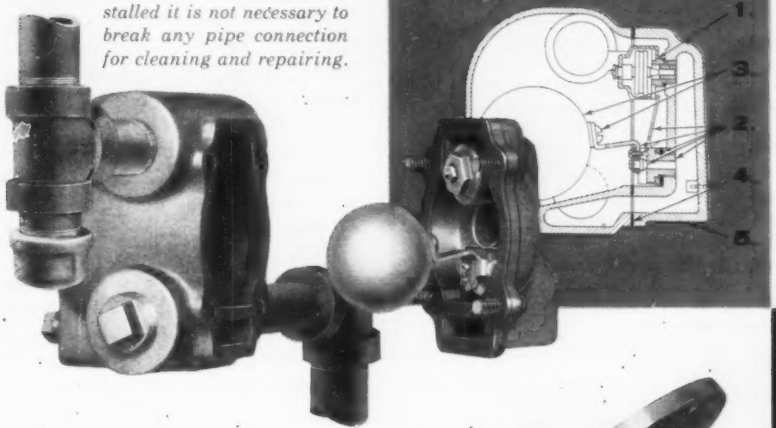

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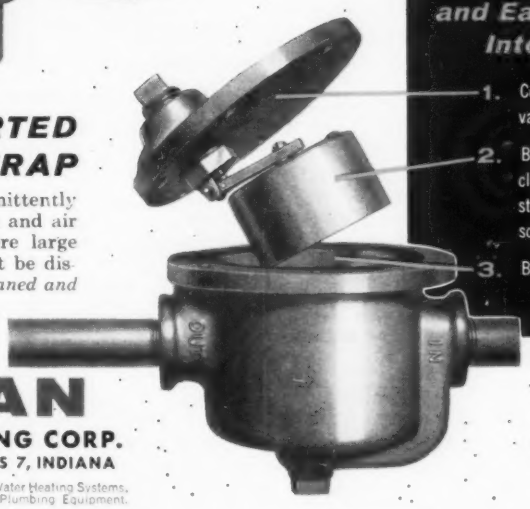

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3. Body with gasket and drain plug.

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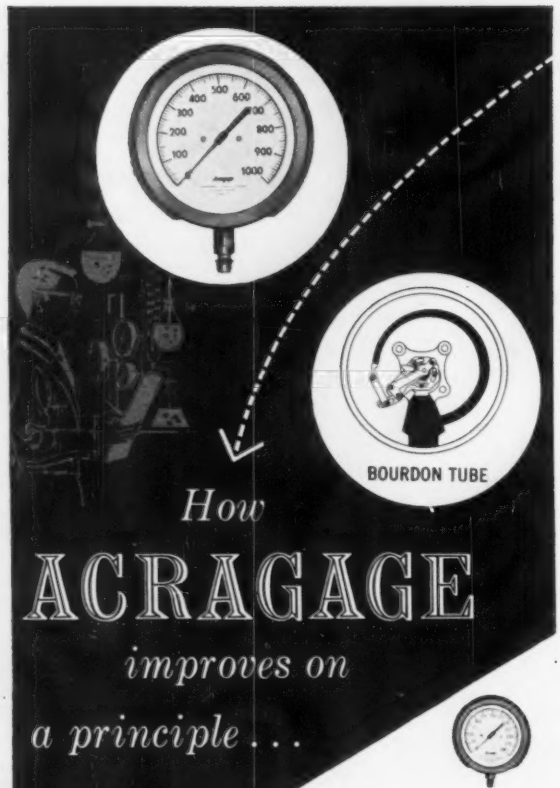
For full particulars, write for catalogs on Bucket Traps, Float and Thermostatic Traps or Thermostatic Traps.



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Marmaduke

Continued from page 144

"BILGEWATER on finding business on the West Coast. I'll tell you about finding lost Btu's in a ship's plant that had everyone stopped, and all I used was nature's thermometer."

That sudden outburst was unexpected, but most welcome. I plopped down on the ship's settee, all ears to hear another of Marmy's unusual experiences. The old consultant revved up his induced-draft blower, sent a No. 3 Ringlemann smoke screen into the room, then continued to blast away.

"Back in 1944 I was trouble-shooting at the U.S. Naval Base at Pearl Harbor. One morning the operations officer asked me to make a trip on the Liberty ship *SS Gull*. She had been built only a year before, but her fuel consumption was way up around 0.95 barrels per mile, instead of the 0.70 barrels being chalked up by the other ships of her class. The boss told me that various engineers had tried to find those lost Btu's, but no soap.

"Next morning we shoved off in convoy for Eniwetok. After breakfast I started to look through the chief engineer's files, checking temperatures and pressures in the log sheets, blueprints of piping systems, everything I thought might give me a clue to the trouble. But I found nothing to put me on the beam.

"Like most Liberty's she had a 2500-hp triple-expansion reciprocating steam engine. Two crossdrum watertube boilers supplied the steam.

"Going below for a look-see, I found her vacuum of 27 in. normal, according to her heat-balance diagram. So was her 120-F condensate about right. A check of her combustion efficiency showed it was around 80%. During lunch I told the chief engineer that his triple-expansion engine was probably the culprit.

"He told me he had the same idea when joining the ship, and that he'd taken a lot of indicator diagrams. They were all OK. But to make sure, he said he had opened each valve and cylinder on the engine and either renewed or expanded all the piston rings. For good measure he replaced the slide-valve guide strips to prevent steam leakage.

"After examining his indicator cards I had to admit his engine

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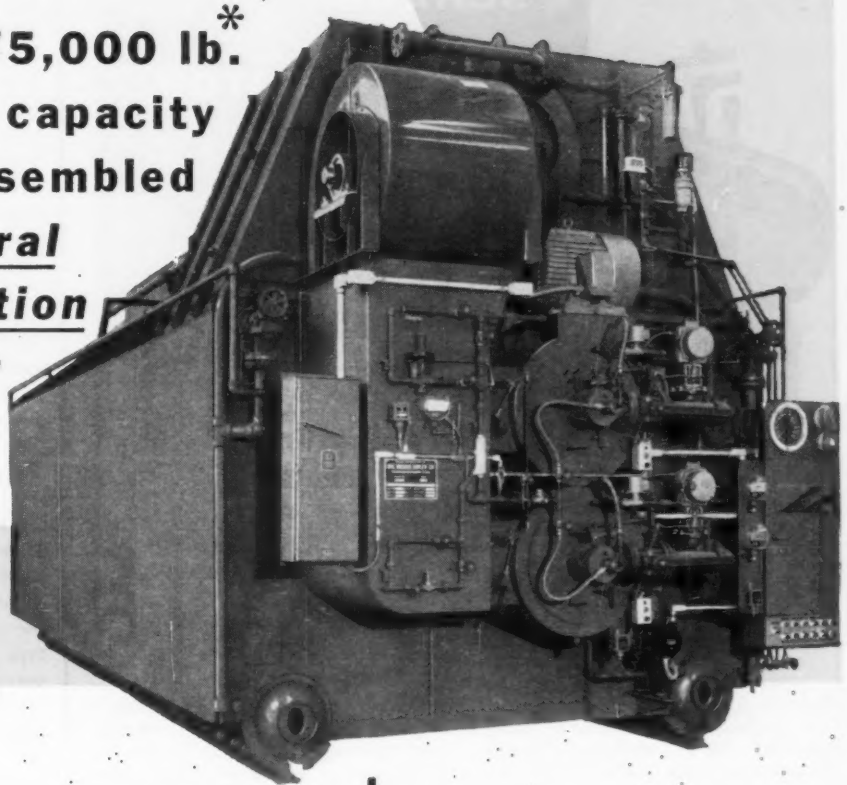
a new 75,000 lb.* per hour capacity shop-assembled *natural circulation* boiler



*75,000 lbs. per hour present capacity.
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169

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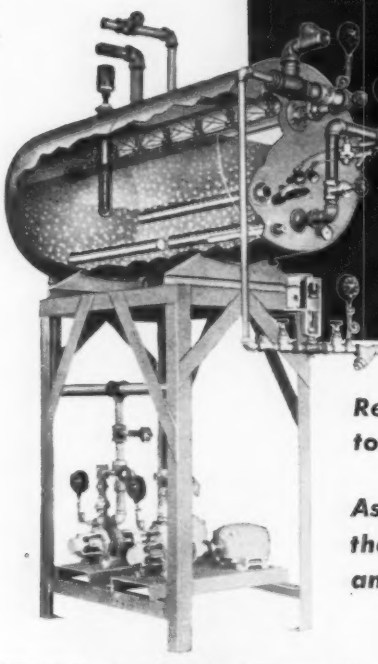

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Whether you reckon in original cost or the operating savings you'll achieve, no other deaerator in the 3000 - 45,000 lb. range offers you so much protection for so little. For fuller information on the remarkable "hows" and "whys" and savings advantages of the Schaub .03 Deaerator method, send for Bulletin 1300.

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Please send me, without cost or obligation, my personal copy of your Bulletin 1300 on Boiler Feedwater Deaeration.

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Marmaduke

Continued from page 208

seemed to be in good condition. But there was that 0.95 barrels per mile of fuel oil staring me in the face.

"By evening I was dizzy from climbing all over the machinery checking pressures, temperatures and figuring fuel consumption. So I was happy to go topside and take a cold shower and sit down to a good meal.

"'Everything points to some of your thermometers being cockeyed,' I told the chief. 'Your temperatures just can't be right, not with your engine and boilers in perfect condition while you burn up all that extra fuel.'

"'I thought of that the last time we made Pearl Harbor from the Mariana Islands,' he answered. 'So I had every thermometer and pressure gage in the steam and condensate cycle renewed. Not one reading is out more than a few degrees or a few pounds.'

"I had to admit I *could* be wrong. That problem had me buffaloed, so after dinner I went below again. I tackled the feedwater system again, climbing from the floor plates up to the grating, around the shell-and-coil type heater. The heater's outlet temperature read 240 F. The thermometer was on the heater outlet line, just before the outlet stop valve. That 240 F was perfect, but with feedwater heated to the right temperature by exhaust steam from the auxiliaries, I just couldn't see where those Btu's were hiding . . . not in a plant that was as shipshape as this one seemed to be.

"Then I studied her feedwater heater piping. The 4-in. feed line from the feed-pump discharge to the boiler steam drums was a foot above the heater. Two 90-degree, combination inlet-bypass valves in the feed line hooked into the inlet and outlet side of the heater's coils.

"You could bypass the heater by closing the two-seated inlet and outlet valves. I tried the inlet valve but it was open, as it should be. So it looked like the 120 F feedwater from the hotwell had to be passing through the heater coils. The thermometer was installed on the outlet line, under the outlet valve—nothing wrong with that.

"But seeing isn't believing—not in a power plant. So I touched the out-

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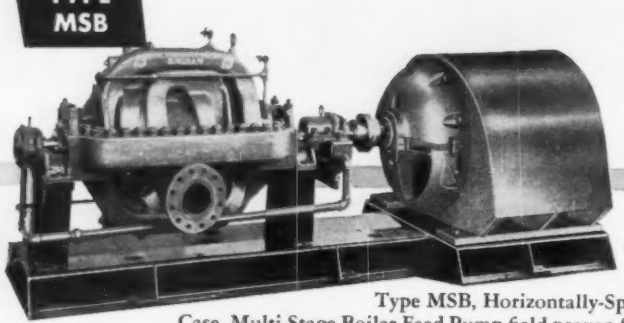
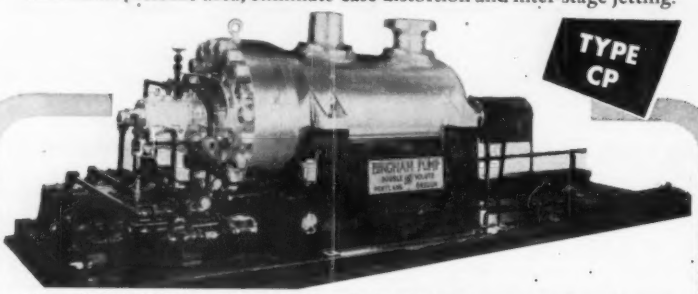
TYPE MSB



Type MSB, Horizontally-Split Case, Multi-Stage Boiler Feed Pump field proven for 1200 lbs. working pressure. Integrally cast cross-overs and evenly spaced case bolting located uniformly close to the shaft center line, enclosing a minimum pressure area, eliminate case distortion and inter-stage jetting.

TYPE CP



Type CP, Multi-Stage, Double-Case Boiler Feed Pump with forged outer barrel for high pressure service.

All BINGHAM Boiler Feed Pumps feature: (1) "Double Volute" construction, resulting in full radial balance of the rotating element *throughout the entire operating range of the pump.* (2) Double suction first stage for low NPSH. (3) Balanced axial thrust (no balancing drums needed). (4) Kingsbury Thrust Bearings. (5) Stuffingboxes subjected to suction pressure only. (6) Design for High Speeds.

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Marmaduke

Continued from page 210

let line's flange slightly beyond the valve expecting a burn from that 240 F. But the flange was only warm, not more than 130 F at most. I had struck gold. *That* was the trouble—no mistake about it.

"I sent an oiler up to the chief's room. When he came below I asked him to cut out the main feedwater system and change over to the auxiliary system. That would circumvent the feed heater completely. Then he could remove the inlet valve's bonnet and see what was wrong—if the trouble was in the valve.

"When the valve bonnet was removed, we found the upper seat had backed out of its threads and fallen out. Because there was no upper seat, the stem had been screwed out when opening the valve until the valve disk was above the normal position of the upper seat.

"With both the heater inlet and bypass wide open, most of the feedwater was bypassing the heater because it was the path of least resistance. The small amount of water passing through the heater was naturally at backpressure temperature. But because the thermometer was submerged in the hot outlet water line before it hit the cooler bypassed water over the valve disk, the water read 240 F.

"I had the machinist bore out the seat threads, make a new seat to fit, and close the valve. After the heater was cut in, the fuel consumption dropped to 0.68 barrels per mile because the rest of the plant was in such good shape.

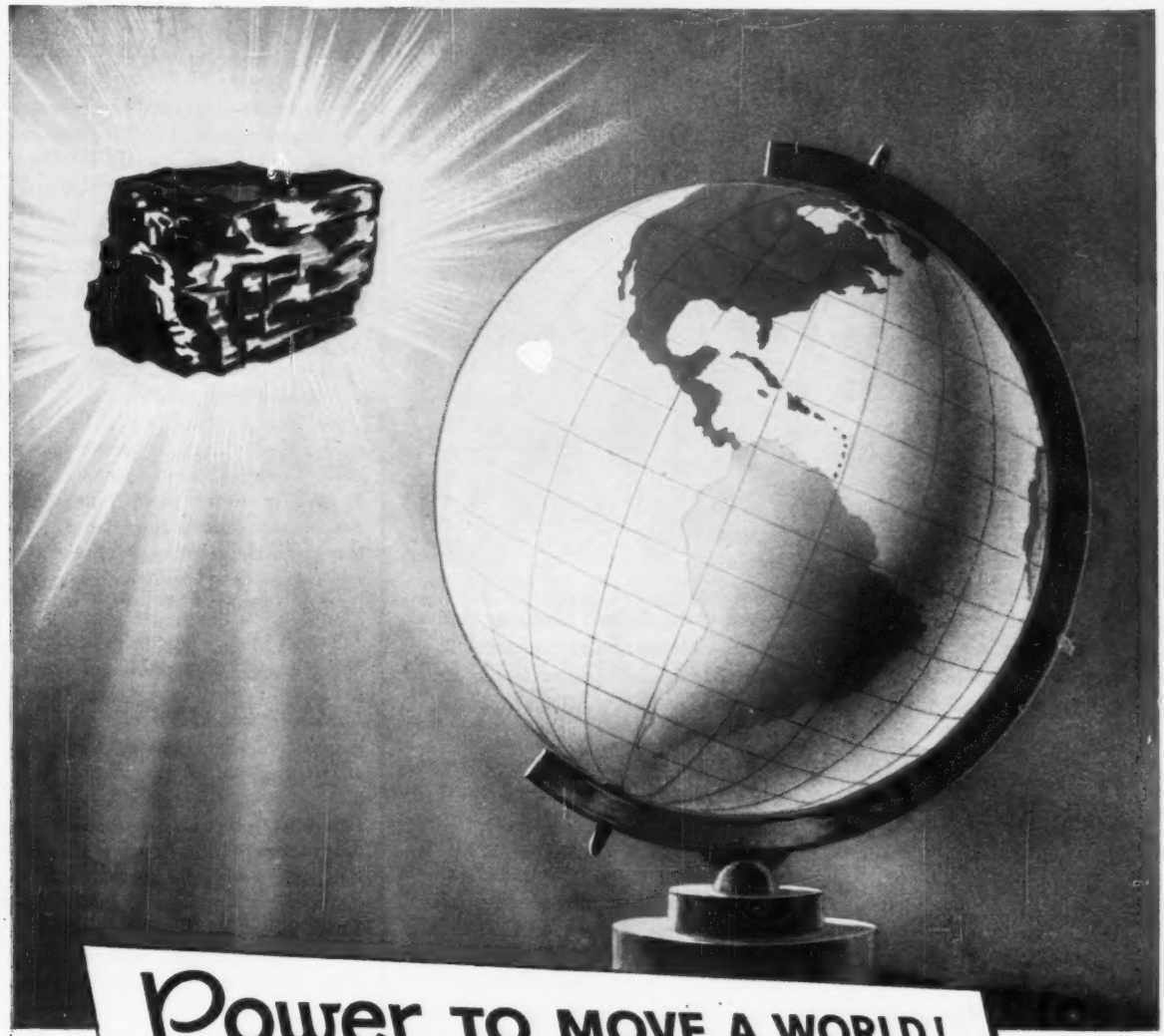
"That solved the mystery," roared Marmaduke, lighting up a new piece of rope yarn. "You can't beat nature's own thermometer as a trouble shooter for low temperatures. But there's one thing you've got to know to use it," he bellowed, looking a hole right through me.

"What's that?" I asked, slightly startled.

"You've got to know *where* to use it," he roared.

Then he leaned back into his swivel chair, plopped his feet up on top of his desk, and closed his eyes.

I started for the door. By the time I landed on the bottom step I heard a ferocious snarl, like some wild monster in a death struggle.—*SME*



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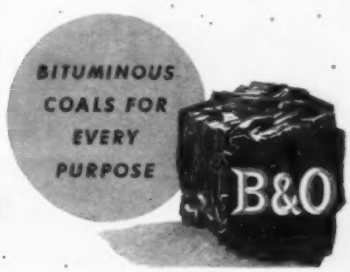

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If you can draw circles with a compass you can cut perfect gaskets in seconds with this handy kit. Just set the blade for the desired thickness, set the pivot post at the desired diameter, and a smooth swing of the cutter gives you a clean, accurate gasket . . . from a ¼ inch bolt hole to a 60 inch outside cut. Larger diameters can be cut with additional extension arms.

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Bookshelf

Techniques of Plant Maintenance & Engineering, 1958. *Published by Clapp & Poliak, Inc, N. Y. 8½ x 11, 211 pages, cloth on board, $10.00 postpaid.*

Ninth in series, book reports proceedings of Plant Maintenance & Engineering Conference held in Chicago last January. Included are texts of 35 papers, texts of some 450 questions and answers, 42 charts, tables and illustrations.

Subjects covered are: "How we analyzed our maintenance management," welding in maintenance, how to save on electric power bills, maintenance in little plants, labor relations, fundamentals of preventive maintenance, and many others.

EDITOR'S NOTE: *These three textbooks have recently been published on the subject of electromagnetic theory. Each uses a different approach and covers somewhat different aspects of electromagnetic engineering.*

Introduction to Electromagnetic Engineering. *By Roger F Harrington, Electrical Engineering Dept, Syracuse University. 312 pp, illust; $8.00. McGraw-Hill Book Co, Inc, 330 W 42nd St, New York 36, N. Y.*

A textbook on electromagnetic theory based on circuit theory rather than on the classical force-relationship approach. A knowledge of calculus and circuit theory is prerequisite; vector analysis is introduced and used as needed. Primary emphasis is on static fields, but the relationship of static to time-varying fields is established. Numerous questions and problems are provided at the end of each chapter.

Engineering Electromagnetics. *By William H Hayt Jr, Associate Prof of Electrical Engineering, Purdue University. 328 pp, illust, $8.50. McGraw-Hill Book Co, Inc, 330 W 42nd Street, New York 36, N. Y.*

This text uses Maxwell's equations as the central theme. These equations are developed from the historical approach in which the several experimental laws are introduced. Several applications of Maxwell's equations are described, including circuit theory, skin effect, wave motion and

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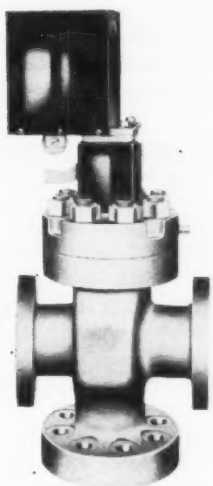
minimizes leakage and maintenance



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Consolidated Electromatic® Relief Valves save steam, pure water, fuel, and "wear and tear" on your spring-loaded valves. Pressure loaded seating permits closer adjustment between operating pressure and set point than in spring-loaded valves. Many Electromatics are used to purge superheaters for faster startups and as superheater vent valves. They greatly reduce chances of superheater damage when firing up a cold steam generator or banked boiler.

Pressure loaded seating is created by channeling steam from the pressure vessel around the Electromatic's exhaust and into its main and pilot valve chambers. Steam pressure in both chambers always matches that in the vessel when the Electromatic is closed.

When pressure exceeds the Electromatic's set point, a signal from controller to panelboard control station results in solenoid thrust that opens the pilot valve, venting the steam faster than it can enter the pilot valve chamber through the clearance between the main valve disc and guide. With pressure in the chambers unbalanced, the main valve opens; steam exhausts until boiler pressure is reduced to the pre-determined setting of the controller. The pilot valve and the main valve close instantly at this point. Action is so fast, the closely adjusted Consolidated Electromatic normally relieves overpressure before the spring-loaded valve's set point is reached. For automatic or manual operation or to cut the valve out of service, a switch is provided on the control station. Send for Bulletin 720.

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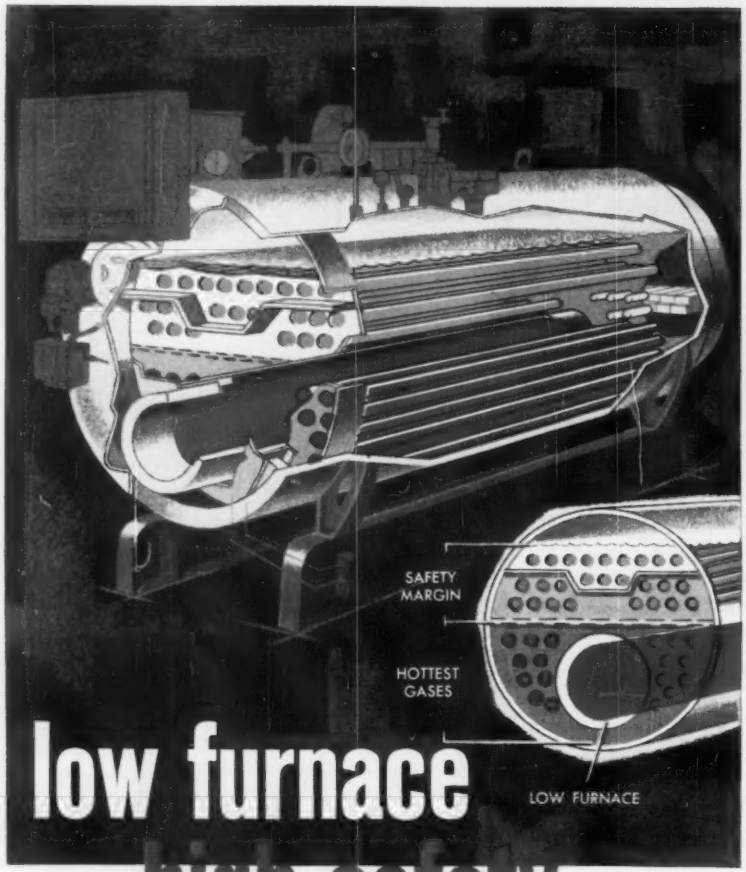

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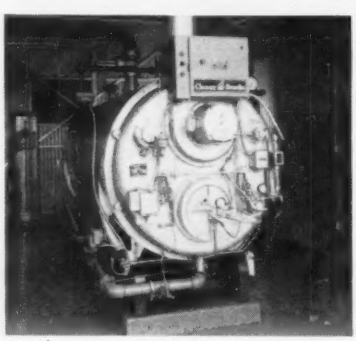

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Bookshelf

Begins on page 214

radiation. The first chapter introduces vector analysis, and this is developed along with electromagnetic theory. Excessive involvement with analytic geometry and its detailed use in interpreting the electromagnetic fields is avoided.

Introduction to Electromagnetic Fields. *By Samuel Seely, PhD, Prof and Head of Electrical Engineering Dept, Case Institute of Technology. 308 pp, illust, $8.50. McGraw-Hill Book Co, Inc, 330 W 42nd Street, New York 36, N. Y.*

The author proceeds from a consideration of the study of current-flow fields, to the static-electric field, the static-magnetic field, then to dynamic fields. In addition to the general aspects of electromagnetic fields, the sources and points of development of forces and torques in such fields and the general features of energy storage, energy flow, energy transfer and energy conversion are taken up. The book begins with a discussion of scalar fields and then leads into vector fields. A knowledge of calculus and an understanding of the important concepts of mechanics is assumed.

High Dams and Upstream Storage (1958). *Edited by Albert W Stone. 175 pp, 5½ x 8½, illust, tables, cloth. Montana State University, Missoula, Montana.*

This book is a companion to the volume on the "Preference clause" published last year. Both are the result of two annual water-resource conferences held under the direction of the University's law school. This volume includes 13 papers, applying particularly to the Pacific Northwest, presented under the general titles: Flood control; Hydroelectric power; Other needs for stored water; Problems of upstream states; Proposed Paradise Dam project in Montana.

The papers cover both upstream and downstream needs, but concentrate on physical facts as they affect people, ignoring political and economic considerations. The book helps to place problems of dam building in perspective, taking into account regional and local problems that occur at most dam sites.

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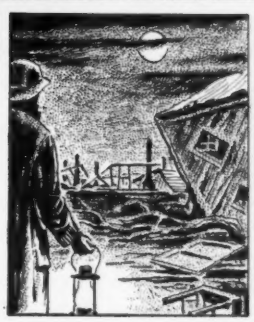

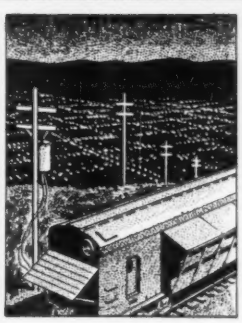

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12 HOURS AFTER MOVING INTO A DISASTER AREA, THIS GAS TURBINE PLANT ON WHEELS DELIVERS 6,500 KW– OVER 12 TIMES THE POWER OF THOMAS EDISON'S ORIGINAL PEARL STREET STATION. TRANSITION SECTION OF UNIT'S GAS TURBINE, WHICH CHANNELS 1350°F GASES TO BLADES, IS INCONEL* NICKEL-CHROMIUM ALLOY. INCONEL ALLOY RESISTS CORROSION, OXIDATION, LOSS OF STRENGTH AT HIGH TEMPERATURES.

How the tube that couldn't be straightened started instrumentation

TRYING TO STRAIGHTEN A TUBE, INVENTOR BOURDON, CLOSED ONE END AND INJECTED HIGH PRESSURE STEAM. TUBE STRAIGHTENED ...BUT SNAPPED BACK WHEN STEAM WAS GONE! THUS WAS BORN THE BOURDON GAUGE...AND MODERN POWER INSTRUMENTATION. TODAY, MANUFACTURERS MAKE MANY HIGH PRESSURE BOURDON GAUGE TUBES OF "K" MONEL*. THIS NICKEL-COPPER ALLOY IS EASY TO FABRICATE, TAKES PRESSURES UP TO 100,000 PSI, HAS MINIMUM HYSTERESIS.

Having trouble with a metal problem?

TEAMING UP WITH INCO'S MECHANICAL ENGINEERING SECTION MAY HELP YOU COME UP WITH A PRACTICAL SOLUTION. AS A STARTER, WRITE **DEPARTMENT PE** FOR TECHNICAL BULLETIN "ENGINEERING PROPERTIES OF 'K' MONEL"

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street — New York 5, N. Y.

INCO

*Registered trademark

INCO NICKEL ALLOYS

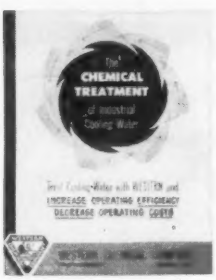
Write Western Today!

For these technical bulletins on

Water, Steam & Fuel Treatment

The Chemical Treatment of Boiler Feed Water. This technical bulletin contains a clear explanation of the causes of boiler water problems and Western's methods of solving them. Special emphasis on scale prevention, corrosion control, sludge dispersion, and suppression of foaming and carry-over.

Steam Plus CORAVOL Equals Protection From Corrosion. This technical bulletin tells how CORAVOL, the original amine process, gives complete protection from corrosion to your entire steam-condensate circuit. Clearly explains the theory of corrosion and the application of volatile amines to steam systems. Cites typical case histories of the use of CORAVOL in various plants and industries.



The Chemical Treatment of Industrial Cooling Water discusses common cooling water problems—scale, corrosion, algae, slime. Also presents Western's proven methods for controlling and preventing these conditions in cooling towers, evaporative condensers, process heat exchangers, engine and compressor jackets, chilled water systems, etc.

Better Fuel Performance and Economy discusses the causes and effects of sludge in fuel oil supplies and soot deposits in combustion areas. Shows how these troubles can be eliminated economically, dependably, and permanently with time-tested special Western formulas.

Also, Technical Bulletins on the chemical treatment of potable and plant water supply—refrigerating brine—sweet water systems. Also, the use of Dry Acid Scale Removers.

WESTERN CHEMICAL COMPANY — PIONEERS IN CHEMICAL WATER

Whatever your water, steam or fuel treatment problem may be, you can rely on special Western formulas and individual technical service to solve it dependably and economically.

WESTERN CHEMICAL COMPANY

713 Washington Street, Kansas City 5, Mo.

Appointments

Corporation changes

Republic Flow Meters Co: W F Crawford, president; J D Cunningham, board chairman. **Crosby Valve & Gage Co** and **The Ashton Valve Co:** Erling Klafstad, president. **Koehler Aircraft Products Co:** R M Johnson, president.

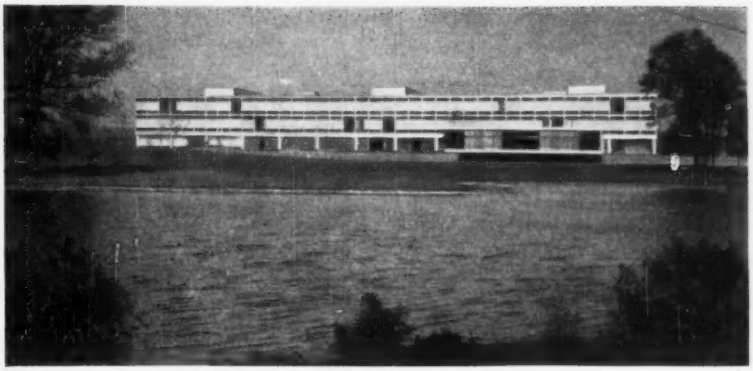
Chase-Shawmut Company: P G Johnston, president. **Ionics, Incorporated:** L A Rupp, vice-president and general manager. **Oakite Products, Inc:** G M Seib, vice-president. **Beckman Instruments, Inc:** Robert Erickson, executive vice-president. **Milton Roy Company:** Paul Gibian, vice-president of manufacturing.

Infilco Inc: W M Gross, vice-president. **Rome Cable Corporation:** A M Ziegler, vice-president. **Minneapolis-Honeywell Regulator Co,** Industrial Products Group: G M Muschamp, vice-president, engineering; J M Wilson, director of engineering. **Thomas A Edison Industries:** William Balentine, vice-president.

Operations changes

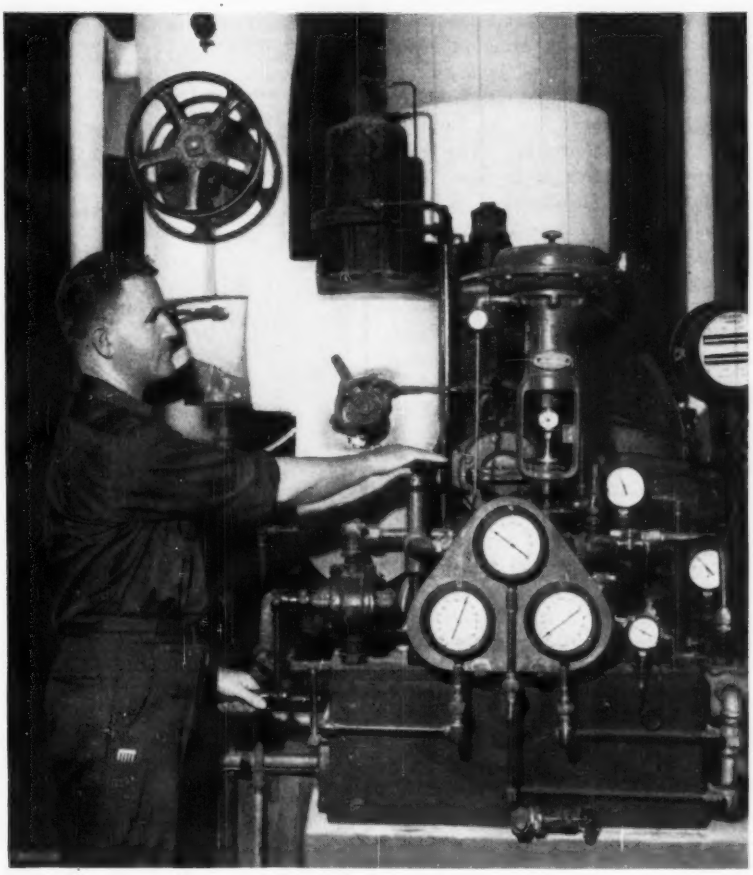
Consolidated Diesel Electric Corporation of Canada, Ltd: Eric Sullivan, general manager. **Penberthy Manufacturing Company:** H E Strohmaier; general manager. **Cummins Engine Company, Inc:** Reece Hatchitt, director of international operations. **Westinghouse Electric Corporation,** fuel products section: R W Brown, manager; R E Bish, engineering section manager.

Worthington Corporation, Compressor & Engine Div: E J Tribble, group vice-president. **Black, Sivalls & Bryson, Inc,** Controls Div: C R Bootz, manager. **Hoover Ball and Bearing Company,** Ball and Bearing Div: R C Ressler, general manager; J C Carman, assistant general manager. **Carrier Corporation,** Research and Development Div: Elbridge Gammill, director of project qualification. **General Electric Company,** Gas Turbine Dept: C W Elston, manager of engineering; Large Steam Turbine-Generator Dept: J E Downs, manager of turbine engineering; E H Miller, manager of turbine advance engineering; DC



New home office for Connecticut General Life is a modern structure five miles out in the country.

Terry turbines power air-conditioning system at new Connecticut General Life building



One of two 870-hp, 3970-rpm Terry turbines built to drive the refrigeration compressors.

The new home office of the Connecticut General Life Insurance Co., in suburban Hartford, represents the best in contemporary architecture as well as construction techniques and materials.

In keeping with the careful planning evident throughout the project, two Terry turbines were selected to drive the York centrifugal refrigeration compressors. Terry turbines such as these have a record of low maintenance and consistent reliability under varied conditions. The steam generators, which are used for general heating during the winter months, furnish the power to operate the turbines. This provides an economical and dependable air-conditioning setup.

The steel and glass building accommodating 2500 employees overlooks New England farmland. It is furnished with modern equipment, to step up the efficiency of clerical work. Other amenities: lounges, game rooms, cafeteria, bowling alleys, barber and beauty shops, variety store, medical department.

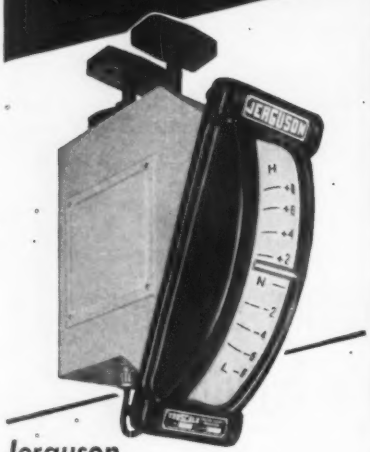
If you are planning an air-conditioning system, perhaps you, too, should consider steam-turbine drive. Write for detailed information about the advantages of turbines for your specific requirements.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1213

Now you can
Have Your Gages
Face UP or DOWN



Jerguson

NEW INCLINED TRUSCALE

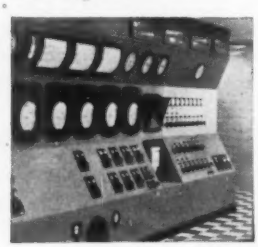
Remote Reading Gages

Have your Remote Reading Gages face up or down . . . to fit low or high installations. Inclined Truscales built with case and scale inclined either upward 35° or downward 24°.

Truscales give you accuracy of ½ of 1% of scale reading and full 180° visibility with scale markings directly on convex face.

Truscale Gages inclined upward in fireroom of SS Flandre

All types of warning signals: Flashing red scale, signal horns, lights and up to six repeaters.



Truscale Gage inclined downward on control panel at Florida Power Corp.

Send for Data Unit on Truscale Inclined Gages.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities
Bailey Meters & Controls, Ltd., London, Eng.
Controle Bailey, Paris, France

Appointments

Begins on page 218

Motor and Generator Dept: W F Oswalt, general manager.

Purolator Products, Inc: F R Gruner, director of engineering. **United States Rubber Co,** mechanical goods div: W E Combs, manager of development; Dr T L Wilson, Research Center manager. **York Corporation:** A B Newton, engineering director. **Mid-Century Instrumatic Corp:** Philip Balaban, research director. **Alloy Manufacturing Corporation:** E S Wolslegel, manager of project engineering. **Zurn Industries, Inc,** Fluid Control Div: T A Kennedy, general manager.

Consultant changes

Schupack and Zollman, 211 E 37th St, New York, N. Y.: consulting civil engineers specializing in design of concrete liquid and bulk storage tanks; industrial buildings. **Ned Nyberg,** 5912 Nagel Ave, St. Louis 9, Mo.: welding consultant. **The Foxboro Company:** H S Bean, flow-measurement consultant.

Sales vice-presidents

International Rectifier Corporation: J T Cataldo. **Oakite Products, Inc:** Eustace Lingle, industrial sales. **Purolator Products, Inc:** Jules Kovacs, technical sales. **E F Houghton & Co:** Frank Ross.

General sales manager

Pittsburgh Piping and Equipment Company: A S Hamley Jr. **Crane Co:** D R Nordwall. **Rome Cable Corp, T J Cope Div:** R M Wade. **Power Plant Equipment Limited:** J T Smith. **Tuthill Pump Company:** M J McCaughey. **General Motors Corp,** Electro-Motive Div: H P Gustavson, electric utility sales.

Hoover Ball and Bearing Company: J T Miller Jr, bearing sales. **Bell & Gossett Company:** D C Broadwell, export manager. **Allis-Chalmers Manufacturing Company,** control dept: G G Brooks, product sales. **Kerrigan Iron Works, Inc:** H K Cropsey. **General Electric Company:** J F Smith, industrial and specialty distributor sales. (*Continued on page 228*)

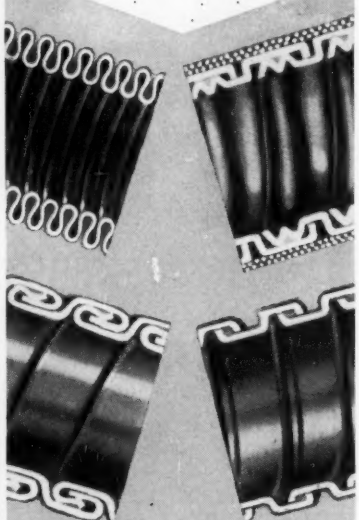
FLEXIBLE TUBING
FOR EVERY APPLICATION
...PRODUCT...PURPOSE

PENFLEX

Interlocked, corrugated . . . braided, plain or rubber covered . . . copper, steel, brass or stainless steel . . . from ⅛" to 24" I.D. Penflex makes all types and sizes for all applications and operating conditions.

Penflex Flexible Metallic Tubing is made for rugged, long lasting service. It defies heat, abrasion, crushing . . . will convey everything from semi-solids to the lightest volatile. Get full information. Write . . . Pennsylvania Flexible Metallic Tubing Co., Inc., 7237 Powers Lane, Philadelphia 42, Pa.

NEW DATA BOOK
Get your free copy.



PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

Announcing a new book of utmost value to Designers and Users of Atmospheric Heat Exchange Equipment

"EVALUATED WEATHER DATA FOR COOLING EQUIPMENT DESIGN"

This book is an evaluated summary of 10 million summer hourly observations spanning 10 years at over 400 official United States, Canadian, and Mexican weather stations.

Staff-prepared by recognized authorities, it presents in text, table and map form the 1%, 5% and 15% design levels of wet bulb temperatures at each weather station. Other values presented include dry bulb temperatures, and wind speeds and directions coincident with the high wet bulb temperatures.

"Evaluated Weather Data for Cooling Equipment Design" is the most complete and up-to-date weather data manual ever presented to designers and users of atmospheric heat exchange equipment.

Typical of Data Presented in Chapter and Section Form—

TEMPERATURE VARIATIONS:

Daily variations; Monthly variations of wet bulb temperatures; Annual climatic ranges of wet bulb temperatures; Typical "hot spell" weather sequences.

WET BULB DESIGN VALUES:

Pertinent considerations; Wet bulb temperature tabulations at 3 design levels; Iso-line maps of wet bulb temperature frequency (1%, 5% and 15% design levels); Temperature differences associated with various frequency levels.

COINCIDENT DRY BULB VALUES WITH HIGH WET BULB VALUES:

Tabulation procedure; Coincident patterns on psychrometric charts (49 cities).

WINDS RELATED TO HIGH WET BULB TEMPERATURES:

Velocity changes with height above ground; Daily changes in wind; Upslope and downslope winds; Sea and lake breezes; Winds coincident with high wet bulb temperatures; Determinations of predominant directions; Ranges of velocity; Cooling tower orientation.

DRY BULB DESIGN VALUES:

Frequency of occurrence; Estimating frequency points.

INTERPOLATION BETWEEN STATIONS:

Variation in wet bulb due to elevation; Variation in dry bulb due to elevation; Variation in atmospheric pressure; Air mass modification; Influence of terrain and adjacent operations; Solar radiation; Influence of vegetation; Examples.

$35.00
Per Copy

Copies of "Evaluated Weather Data for Heat Transfer Design" will be available beginning December 1, 1958, through the Fluor Representative in your area. Or, write direct to Fluor Products Company, Department DEW, Whittier, California.

FLUOR PRODUCTS COMPANY

A DIVISION OF THE FLUOR CORPORATION, LTD.

WHITTIER, CALIFORNIA

PERMASEAL® Idlers – installed for 42", 48" and 60" belts at 10,000 ton per day coal handling facility on Ohio River.

NEW-TYPE CONVEYOR IDLERS STRETCH GREASING INTERVALS TO YEARS

Grease 'em by-the-month idlers are expensive to maintain. The Jeffrey PERMASEAL® Idlers in this coal handling system won't need greasing for a year—maybe several years. Their slightly higher initial cost (due to superior bearing protection) is quickly absorbed by unparalleled low cost of maintenance.

Bearing failure is the major cause of idler failure. The PERMASEAL® Idler's unique double seal design protects bearings as they have never been protected before. On coal handling systems and dirty, abrasive handling jobs, Jeffrey PERMASEAL® Idlers are proving their ability to outlast any other idler on the market.

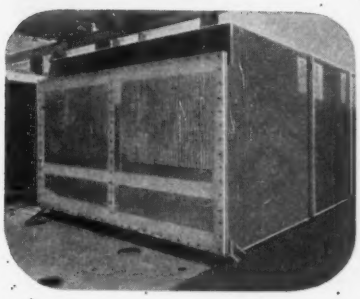
Get more data on PERMASEAL® Idlers. Your materials handling supervisor should have all the facts on PERMASEAL® Idlers. Contact a Jeffrey distributor, or write The Jeffrey Manufacturing Company, 932 North Fourth Street, Columbus 16, Ohio.

JEFFREY

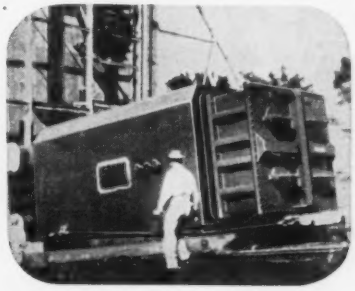
CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

and auxiliary equipment

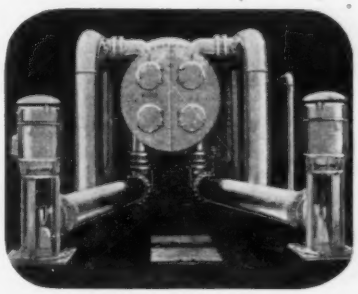
HOW C.H. WHEELER CONDENSER DESIGN saves space...



Head Room problems are solved by compact condensers like this one. Turbine floor to basement floor, in this case, is only 20 ft. The Unit has 65,000 square feet of condensing surface.

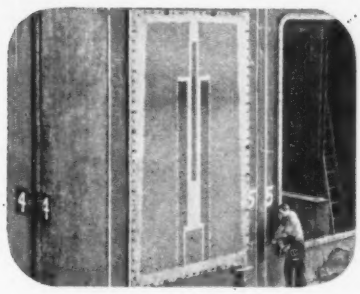


Rectangular Cross Section makes C.H. Wheeler Condensers adaptable to nearly any space or condenser arrangement because the length, width and height of any Wheeler Unit can be varied almost at will.

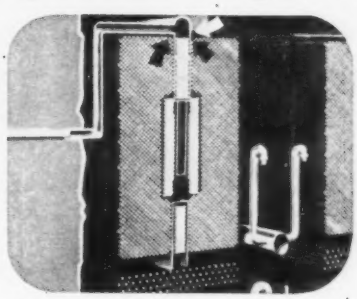


But Wheeler Doesn't limit itself to rectangular design. A round cross section worked out better here, for example, at the first planned gas-steam turbine station ever designed and built in United States.

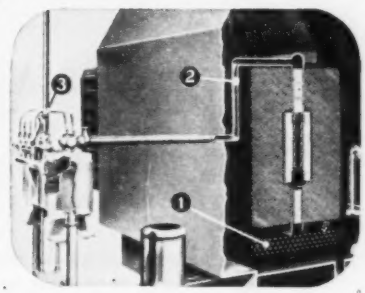
improves power generating efficiencies...



Triple Lane tube layout, another design feature, provides 3 pathways for steam travel, utilizes maximum cooling surface and produces higher condenser vacuums for power generating stations.

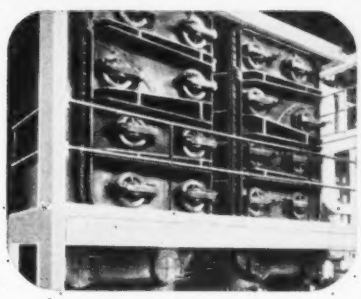


Location of air-vapor takeoff speeds steam travel and allows steam to penetrate to the peripheries of all tubes. It thus improves condenser efficiencies and overall power station operation as well.

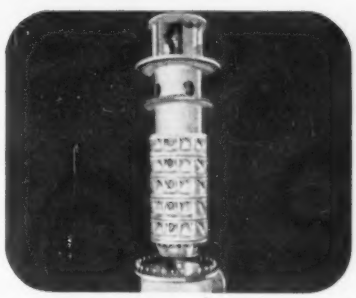


Deaeration of condensate not to exceed 0.01 cc. oxygen/liter is available with special Wheeler designs. Note the Deaerating Bars (1), the Air-Vapor Suction Line (2), and Tubejet® Ejectors (3).

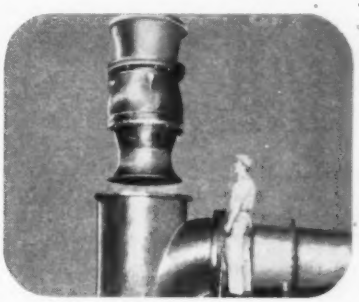
and reduces maintenance



Patented Reverse Flow permits flushing tubes and sheets without shutting down Unit, during full load with either or both circulating pumps operating. No additional circulating water inlet or discharge piping necessary with C.H. Wheeler's Reverse Flow.



"Pull-Out" Condensate Pumps simplify maintenance because entire pumping element, including all rotating parts, can be removed without disturbing either the pump barrel or the piping connections.



C. H. Wheeler Circulating Pumps, like Condensate Pumps, are easy to inspect and maintain because of "Pull-Out" design. In addition, shafts are heat treated alloy steel and impellers are statically and dynamically balanced for trouble-free operation.

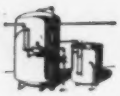
C. H. Wheeler has been designing and building condensers since 1903; has developed such features as Dual Bank Design and Reverse Flow.

C. H. WHEELER MFG. CO.

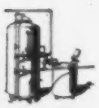
19TH & LEHIGH AVENUE
Philadelphia 32, Pennsylvania

Whenever you see the name C. H. Wheeler on a product, you know it's a quality product

Steam Condensers • Steam Jet Vacuum Equipment • Centrifugal, Axial and Mixed Flow Pumps • Marine Auxiliary Machinery • Nuclear Products

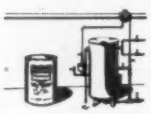


ZEOLITE WATER SOFTENER — manual and automatic. Up to 44% more soft water output from a softener of given size.

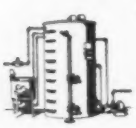


ULTRA-DEIONIZERS — produce highest quality mineral-free water. Replace distillation methods at fraction of distillation cost.

DEALKALIZATION & ION EXCHANGE SYSTEMS—Dealkalizers to control alkalinity. Ion Exchangers to produce water of any desired quality.

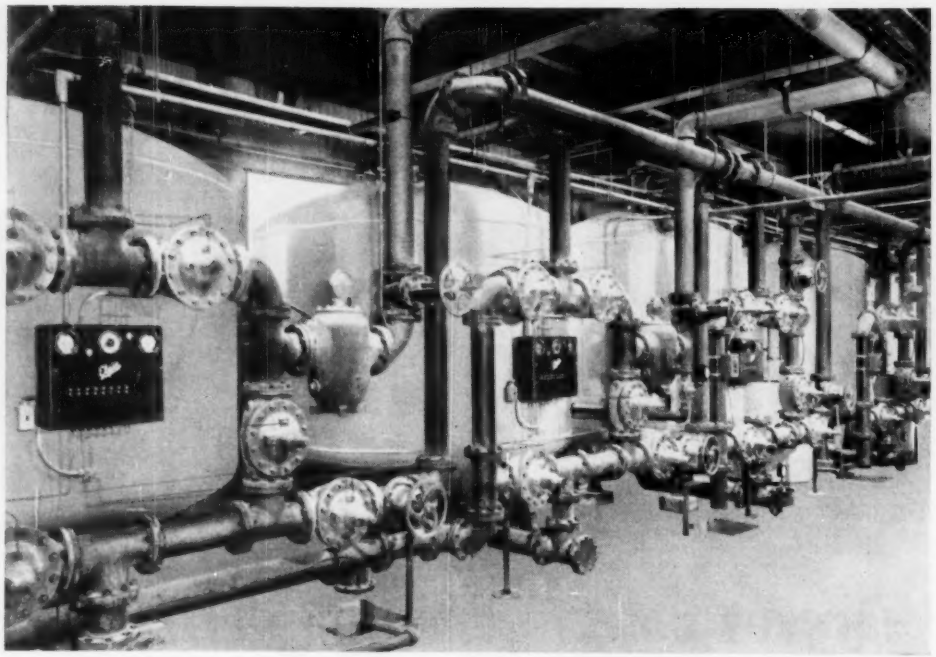


CHEMICAL TREATMENT SYSTEMS—prevent scale, corrosion and depositions with Elgin specially formulated chemicals.



CLARIFIER—for removing excess alkalinity and solids for clarification of turbid waters.

DEGASITORS—for removal of entrained gases from water by aeration.



Typical Elgin Automatic Deionizer

WHO IS QUALIFIED

To handle your water conditioning job?

Today's remarkable advances in water conditioning should suggest methods and equipment that can perform a profitable service for you . . . and this brings up the all-important question:

Who is best qualified to get right down to the practical job of putting these advanced methods to work for you under your specific conditions?

Certainly the best answers will be found in an organization like Elgin that knows and offers *every* modern and authoritative approach to *any* water conditioning problem.

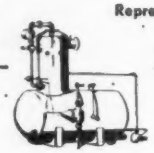
The scope of Elgin equipment and services is briefly touched upon here. To cover the full line would require many pages, but whatever your problem, Elgin with 50 years of intensive specialization is well qualified to solve it. No other organization is better equipped to determine your needs and meet them in the best and most economical way.

Your nearest Elgin Representative would like to put our fifty years of experience to work for you. Or, if you prefer, tell us your conditions and we will send covering bulletins.

ELGIN SOFTENER CORPORATION

130 No. Grove Avenue, Elgin, Illinois

Representatives in Principal Cities *In Canada: G. F. Sterne & Sons Ltd., Brantford*



DEAERATING HEATERS—supply make-up water pre-heated by exhaust steam in which CO_2 and oxygen are eliminated.

WATER FILTERS—Diatomite, sand, anthrafilt, activated carbon and oil removal filters in all types and sizes.

ELGIN WATER CONDITIONING SINCE 1908

Get positive piping protection with

ZALLEA NON-EQUALIZING EXPANSION JOINTS . . .

Zallea Non-Equalizing Corrugated Expansion Joints offer a degree of protection that can't be equalled for absorbing movement of piping due to temperature changes. They protect interconnected equipment by absorbing movements in otherwise rigid piping systems. They are used in low pressure and vacuum lines . . . between stills, tanks, columns, condensers, pumps and similar equipment.

Standard Sizes: 3″ to 72″ dia.; Special sizes to 50 ft. dia. Pressures: Vacuum to 50 psig. Temperatures: to 1600°F.

Special Applications. With the addition of proper components, Zallea Non-Equalizing Expansion Joints can be used as:

Universal Expansion Joints to absorb movement in any direction . . . axially, laterally, angularly, or any combination of these.

Pressure Balanced Expansion Joints to absorb axial movement outside the unit and still carry pressure thrust.

Hinged and Gimbal Expansion Joints for piping systems that cannot be anchored in the conventional manner.

Get the complete story of Zallea Expansion Joints in our new 72-page manual. They are available for any pressure condition to 3600 psig. Write, on your company letterhead, for your copy of Catalog 56.

Zallea
expansion joints

Zallea Brothers • Wilmington 99, Delaware

World's largest manufacturers of expansion joints

Large Zallea Non-Equalizing Expansion Joint installed on deaerating heater of Ford Motor Company's River Rouge plant.

for greater strength . . . easier assembly

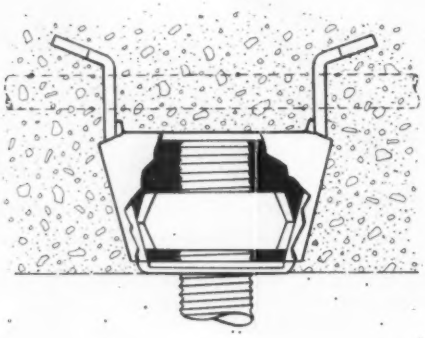
The new Grinnell Wedge Type Concrete Insert

Fig. 281

NEW design features give Grinnell's Wedge Type Concrete Insert (Fig. 281) greater load carrying capacity . . . 1200 lbs. for ⅝" and ¾" sizes, with a safety factor of at least 5 to 1.

Heavy gauge steel is die-formed into a wedge-shaped box housing. When load is attached to the inserted nut and rod assembly, ends of the elongated nut press on the wedge-slanted walls.

These walls, acting in compression with the concrete, provide strength unmatched in steel inserts of equal size.



Preassembly of the elongated nut on the rod makes quick assembly possible.

Installations can be made in quick time, too. Just a few turns of the rod tighten the nut rigidly in place. Slightly loosening the nut permits lateral adjustment along the full length of the slot, without fear of rod and nut falling out of the body.

Single body size accommodates four different interchangeable nut and rod sizes, to make ordering easier and installation simpler—especially where hanger rod sizes cannot be determined in advance of ceiling construction.

On your next project, specify Grinnell Concrete Inserts — either steel or malleable iron. Quality manufactured . . . *and priced right!* Grinnell Company, Inc., Providence 1, R. I.

CB-Universal Malleable Iron Concrete Insert (Fig. 282)

CB-Junior Malleable Iron Concrete Insert (Fig. 279)

Wrought Steel Concrete Insert (Fig. 280)

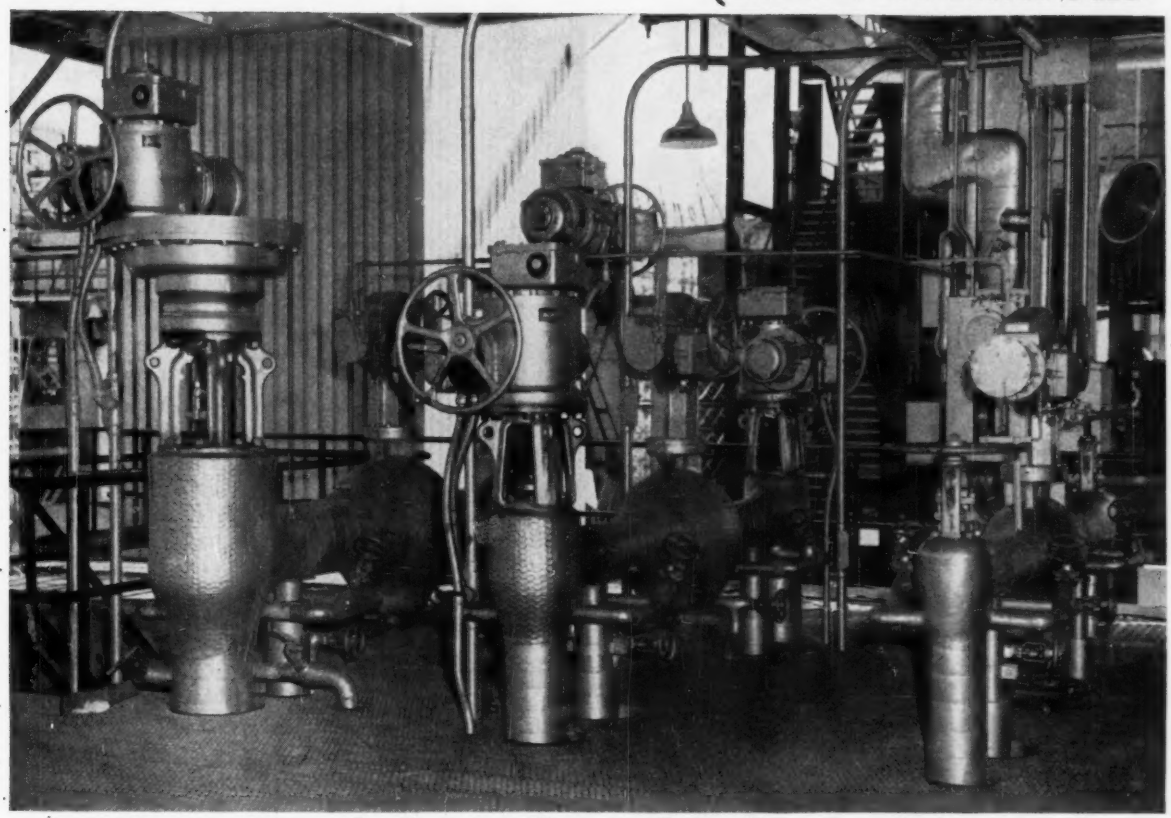
GRINNELL

PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves • Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies • industrial supplies • Grinnell automatic fire protection systems • Amco air conditioning systems

PUBLIC SERVICE COMPANY OF OKLAHOMA...uses LimiTorque VALVE OPERATORS



...on Water Regulating Valves of Boiler Feed Pump Lines

The valves shown are 4", 6", and 10" diameter Wm. Powell Company Gate Valves operated by LimiTorque Motorized Valve Controls. This modern generating station also uses LimiTorque Operators on their 60" Circulating Water Condenser Isolating Valves.

Like many other modern generating stations throughout the world, the Public Service Company of Oklahoma chose LimiTorque Motorized Operators because of their absolute dependability at all times . . . thousands of valves of all types and sizes are being operated day-in and day-out by LimiTorque "push-button" controls—speedily, safely and economically.

With LimiTorque, one key man can, from a central control point, eliminate all guesswork and labor by opening and closing valves in remote, inaccessible, or hazardous locations . . . automatically, speedily, safely and dependably.

LimiTorque is available for actuation by any power source, such as Electricity, Oil, Gas, Water or Air . . . and is also available for microwave control.

LimiTorque controls can be field-mounted on existing valves of all types . . . contact your valve manufacturer or nearest LimiTorque sales-engineering office.

Send for Catalog L-550 . . . and please use your Business Letterhead when requesting a copy.

See us at Booth 141. Power Show Dec. 1st to 5th

THERE IS NO SUBSTITUTE FOR —

LimiTorque®

PHILADELPHIA GEAR CORPORATION

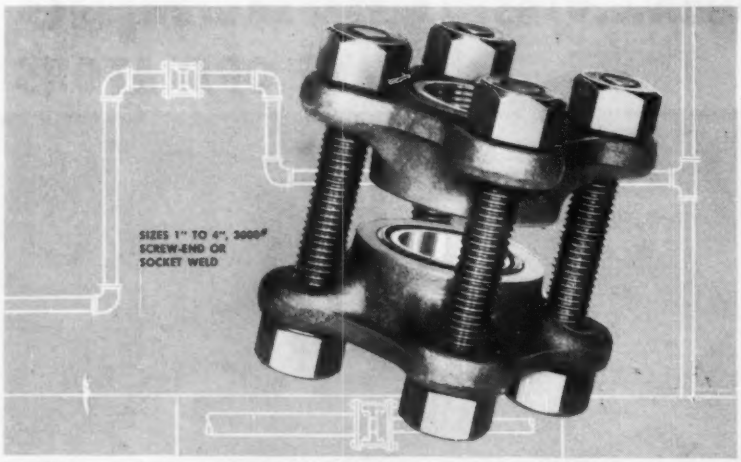
ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.

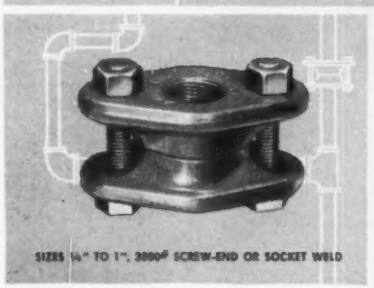
Offices in all Principal Cities

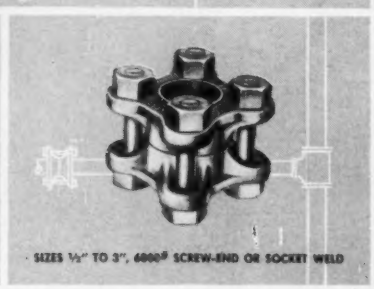
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • Philadelphia

The double diamond assures double value







Installation flexibility with permanent piping strength

GET BOTH WITH W-S O-RING FLANGE UNIONS

NOW, you can install high pressure piping systems that can easily be rearranged and adapted with full assurance that the unions will give the leak-proof service of permanent installations. This is made possible by these adaptable features of W-S O-Ring Flange Unions:

- Available in 2-bolt and 4-bolt types, according to size.
- Sizes ¼" to 1" in 2-bolt 3000#; sizes 1" to 4" in 4-bolt type 3000#; sizes ½" to 3" in 4-bolt type only 6000#.
- Available in Screw-end and Socket Welding Types—3000# and 6000#.
- O-Rings available in a variety of materials for a wide range of service.

Specify forged steel W-S O-Ring Flange Unions for a tight seal against fluid pressure in piping for hydraulic machinery, refrigeration piping, steam and water lines, process liquid and gas lines, and many other applications.

For full specifications, write for Bulletin U-1-58

W-S manufactures a full range of high quality drop forged fittings, unions and couplets . . . in carbon, stainless and alloy steels. For full information about these products, or for your specification forging requirements, write to: W-S Fittings Works, H. K. Porter Company, Inc., Box 95, Roselle, N. J.

H. K. PORTER COMPANY, INC.

FORGE AND FITTINGS DIVISION

W-S Fittings Works, Roselle, N. J. • Cleveland Forge Works, Cleveland 4, Ohio
Stainless Steel Works, Duncannon, Pa.

Appointments

Begins on page 218

Recent purchases, mergers

McGraw-Edison Company and **National Electric Coil Company:** consolidation of the two concerns. **Pfaudler Permutit Inc,** Permutit Div: acquisition of flotation-equipment business of Bulkley-Dunton Pulp Co Inc. **The Cooper-Bessemer Corporation:** acquisition of Creole Engineering, Inc. **Crouse-Hinds Company:** purchase of 50% of the stock of Domex S A de C V, Mexico.

Awards

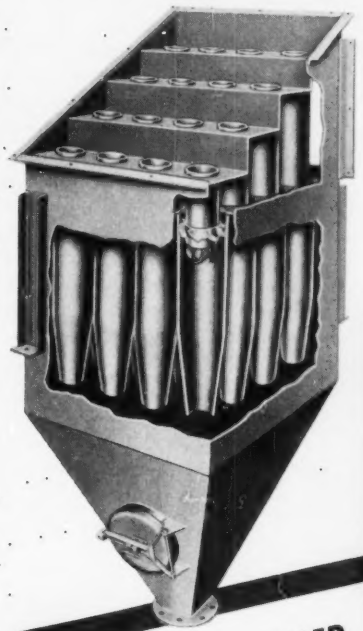
E A Armstrong, General Motors Corp, Electro-Motive Div; **S C Killian,** H K Porter Co, Inc, Delta-Star Electric Div; **Leo Dolkart,** A S Schulman Electric Co; **W C Fowler,** Sangamo Electric Co; **O W Hurd,** Washington Public Supply System; **E P Larsh,** Daytrol Corp; **J W Seanian,** General Electric Co, Power Transformer Dept; **L R Sellers,** TVA; **W G Roman,** Westinghouse Electric Corp, Bettis Atomic Power Div: elevated to Fellow of the AIEE.

F P Fairchild: George Westinghouse medal of the American Society of Mechanical Engineers. **V F Estcourt:** Prime Movers Committee award of the ASME. **John Blizard,** Foster Wheeler Corp; **E L Robinson,** formerly with General Electric Company: honorary membership in the ASME.

W G Brombacher: honorary membership in the Instrument Society of America.

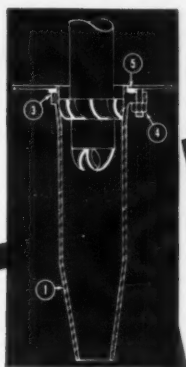
"Better order a new sheath for the compressor—and a new puller."

13 BIG REASONS WHY MULTICLONE FLY ASH COLLECTORS



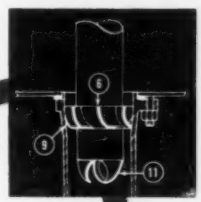
✔ COST LESS TO MAINTAIN...
✔ ARE FAR SIMPLER TO SERVICE!

When you buy fly ash collection equipment, don't stop with a comparison of *initial* cost only. Compare also the cost and simplicity of keeping your collector at top-notch efficiency *throughout the years.* To the outstanding advantages of Multiclone's unique operating features, add the low cost and easy maintenance of this equipment and you'll see why Multiclones are the leading choice wherever *centrifugal* types of fly ash collectors are the most practical solution.



EASILY INSTALLED COLLECTING TUBES

1. **CAST IRON TUBES** assure long wear!
2. **SPECIAL ALLOY TUBES** (FBA Inco #40, Chromehard and Ni-Hard) can be supplied where high temperatures or severe erosion are problems!
3. **TUBES ARE PRECISION-CAST** for exact fit into tube sheet. Tube lip protects sealing gasket!
4. **TIGHT LEAKPROOF FIT** of each tube is maintained indefinitely by special lock nuts!
5. **GAS-TIGHT JOINT** between tube sheet and each tube is assured by special gasket. Joint can be easily renewed when replacing tube!



PRECISION CAST VANES!

6. **CAST IRON VANES** resist erosion!
7. **SPECIAL ALLOY VANES** (FBA Inco #40, Chromehard and Ni-Hard) can be supplied where high temperatures or severe erosion are problems!
8. **VANES ARE EASILY INSTALLED** by simply dropping new ones into place when changing collecting tubes!
9. **EXACT FIT OF EACH VANE** in the tapered collecting tube prevents erosive "blow-by"!
10. **CAPACITY AND EFFICIENCY** of the unit can be quickly altered by simply changing vanes. Assures easy adaptability to new operating requirements — big savings in plant modernization programs!
11. **SPIROVANES** (energy recovery devices) may easily be added to outlet tubes of existing installations to increase capacity or reduce pressure drop!

Plus These Important Advantages...

12. **CUBIC SHAPE** of Multiclone is easier to install and insulate — and requires only ONE simple inlet and outlet duct!
13. **BACKED BY OVER 3300 INSTALLATIONS** serving a wide cross-section of industry, each Multiclone benefits from the unequalled "know-how" gained during Western Precipitation's **half-century** of leadership in the highly-technical field of modern fly ash collection!

Compare the above advantages with any competitive equipment and you'll readily see why Multiclones are the logical choice for *your particular* operations, too. There's a Multiclone representative near you who will gladly supply further details to fit your individual requirements. No obligation, of course!

Send for descriptive literature on Multiclone equipment.

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Jet-Cleaned Filters
THERM-O-FLEX Hi-Temp Filters
TURBULAIRE-DOYLE Scrubbers
HOLO-FLITE Processors
HI-TURBIANT Heaters

WESTERN
PRECIPITATION
CORPORATION

Engineers and Constructors of Equipment for Collection of Suspended Material from Gases and Equipment for the Process Industries

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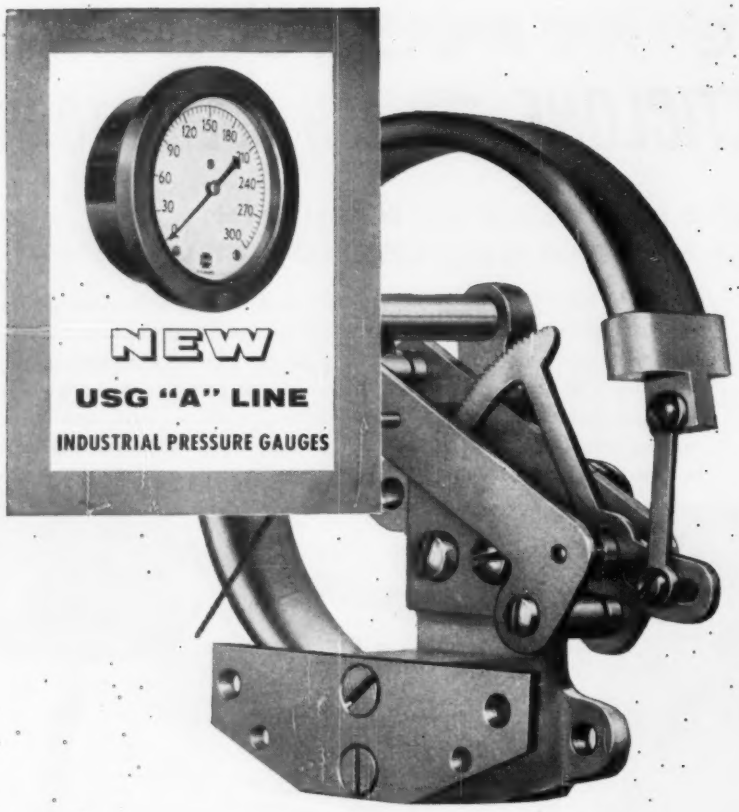
Representatives in all principal cities

Precipitation Company of Canada Ltd., 8285 Mountain Sights Avenue, Montreal 9



WHEN YOU SEE THESE GAUGES, YOU WON'T BELIEVE THE LOW PRICES!

New line of standard industrial gauges has Grade A accuracy . . . premium gauge construction . . . at up to 40% below premium prices

Now, you can buy pressure gauges that are sturdier, more accurate, and have many of the top quality features of premium-priced process gauges . . . yet don't cost a nickel more than you've been paying for general purpose gauges. We guarantee that you can't find better values on the market than our new "A" Line.

Be sure to check the new "A" Line models against your specifications for any of a broad range of industrial applications—principally where steam, water, and oil pressures must be indicated.

Consider such remarkable design points as:

MEETS A.S.A. GRADE A STANDARDS — Guaranteed accurate within 1% of scale for the middle (working) half of scale and 1½% for remainder.

WIDE CHOICE OF OPTIONS—Aluminum cases . standard, other materials available . . . panel or front-of-board mounting . . . variety of movements and Bourdon tubes . . . dial sizes, 3½ to 12 inches . . . for pressures to 10,000 psi or vacuum.

LONG LIFE AND EASY MAINTENANCE—You can select from a wide range of available components to meet your exact needs for rugged or corrosive service conditions, and be assured of maximum life with minimum maintenance. Entire gauge internals can be removed as a unit for inspection or calibration.

Find Your Nearest Distributor In The 'Yellow Pages'

You'll have to see the new "A" Line gauges to believe all the quality features and options offered at amazingly low costs. Ask your U. S. Gauge distributor for a demonstration today, or write for a copy of new Catalog 305.

UNITED STATES GAUGE
DIVISION OF AMERICAN MACHINE AND METALS, INC., SELLERSVILLE, PA.

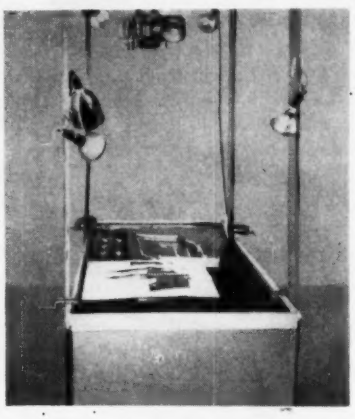
USG

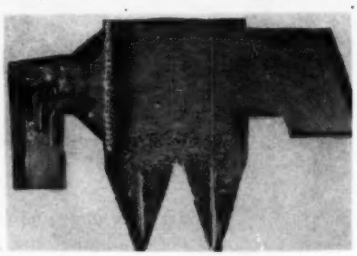
Reports from the field

Begins on page 146

Better efficiency, lowered costs should open up dozens of new uses around the plant.

Advanced developments at Westinghouse include h-t solventless silicones, now going to sea in canned-motor pumps on nuclear submarines and used in control rods of nuclear reactors; sulfur hexafluoride, a gas which can soak up electrons in an arc discharge, may replace oil in tomorrow's circuit breakers and disconnect switches; molybdenum cladding for turbine nozzle vanes and afterburner components; superpressure-steam experiments leading to a turbine, scheduled for '59 startup, which will operate at 1200 F and 500 psi, delivering 325,000 kw.





Water table reproduces precipitator flow patterns

It's now possible to study in two dimensions effects of inlet and outlet duct arrangements on 3-D air-flow patterns in electric precipitators. Water-table system was first used to increase efficiency of collectors in the field. Now it's used for design purposes, and all preliminary ductwork design is tested on the water table. Unit is a 3x5 ft, 5-in. deep water

(*Continued on page 236*)

Developed by ALCO *thermal engineers, this sine-wave tube configuration has pioneered atomic heat-exchanger design.*

THE NEW SHAPE OF THERMAL EXPANSION

Some heat exchangers in atomic power plants are exposed to tremendous fluctuations in temperature. This means, of course, that unusual expansion characteristics must be provided. ALCO engineers have answered this need by designing a unique sine-wave tube that eliminates expansion joints and floating tube-sheets.

Originally designed for America's first atomic submarine, the *Nautilus*, this new concept is currently being applied in other ALCO heat exchangers for major nuclear power plants. The design itself is simple, but it safely absorbs thermal and shock loads through the flexing of the tubes' sine-wave bends.

This new shape of thermal expansion is typical of the advanced design concepts that ALCO builds into all its heat transfer equipment. As a leader in heat exchangers for the power industry, ALCO is now pioneering in the field of thermal engineering for the atomic industry.

For complete information, contact your nearest ALCO sales office or write: ALCO Products, Inc., Dept. 133, Schenectady, N.Y.

ALCO

ALCO PRODUCTS, INC.

NEW YORK

SALES OFFICES IN PRINCIPAL CITIES

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil Field Equipment

100,000 KW power plant addition uses
CHASE ANTIMONIAL ADMIRALTY TUBES

Workers insert first of 8,380 1" O.D. Chase Antimonial Admiralty Tubes used in power plant condenser system. This is part of company's $21,000,000 expansion program to be completed in 1960.

Chase

BRASS & COPPER CO.
WATERBURY 20, CONNECTICUT

Subsidiary of
Kennecott Copper Corporation

There are nearly 50 miles of Chase Antimonial Admiralty Condenser Tubes in this new 100,000 KW generating unit of a prominent Southwestern power company.

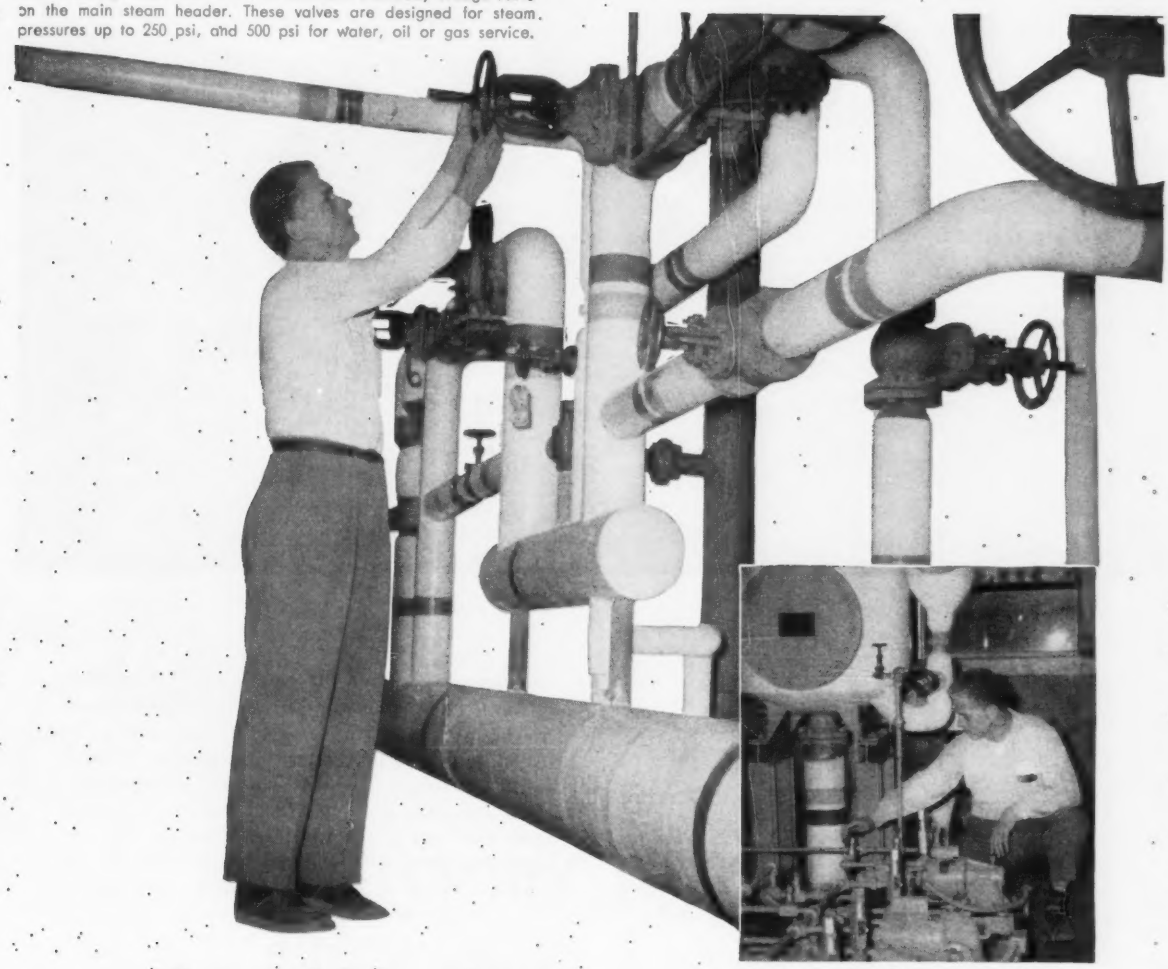
Chase Antimonial Admiralty was chosen because of its favorable cost comparison as well as its enviable "in-service" record. Since Antimonial Admiralty was developed by Chase in 1935, over 125 million pounds of tubes have been put into service in thousands of installations, giving excellent service.

Chase offers unsurpassed technical assistance . . . *first-hand* technical assistance that comes from producing condenser tubes for all types of installations, including raw sea water. For details, contact your Chase representative. Or write Chase, Waterbury 20, Connecticut.

The Nation's Headquarters for Aluminum, Brass, Copper and Stainless Steel

Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York (Maspeth, L.I.) Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

The Chief Engineer closes an 8-inch Walworth Iron Body Wedge Valve on the main steam header. These valves are designed for steam pressures up to 250 psi, and 500 psi for water, oil or gas service.



"from big gates to little globes"...

Chief Engineer Bruce W. Martin checks Walworth Bar Stock Valves in chemical feed pump lines to boiler and feed water. These carbon steel valves are built for ratings up to 3000 psi. Stainless steel bar stock valves are also available for very severe service.

The power plant at the Michigan School for the Deaf has an operating capacity of 25,000 lbs. per hour generated by three 200 hp and one 60 hp oil-fired boilers. Built four years ago, the plant is now the responsibility of Chief Engineer Bruce W. Martin who says: "This plant was designed and constructed for efficient operation and a lot of that efficiency depends on the valves. From big gates to little globes installed here, we use a wide variety of Walworth Valves. They give us the dependable, trouble-free service we want and expect. I would recommend them to anybody for similar service."

Walworth's complete lines of valves are built to provide long range service and savings. There's a Walworth Valve in a type, size, and material to serve you . . . Gate, Globe, Angle, Check, and Lubricated Plug Valves in a variety of pressure ratings. The next time you need valves or have a problem concerning flow control, call your Walworth Distributor, or, write Walworth direct.

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DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

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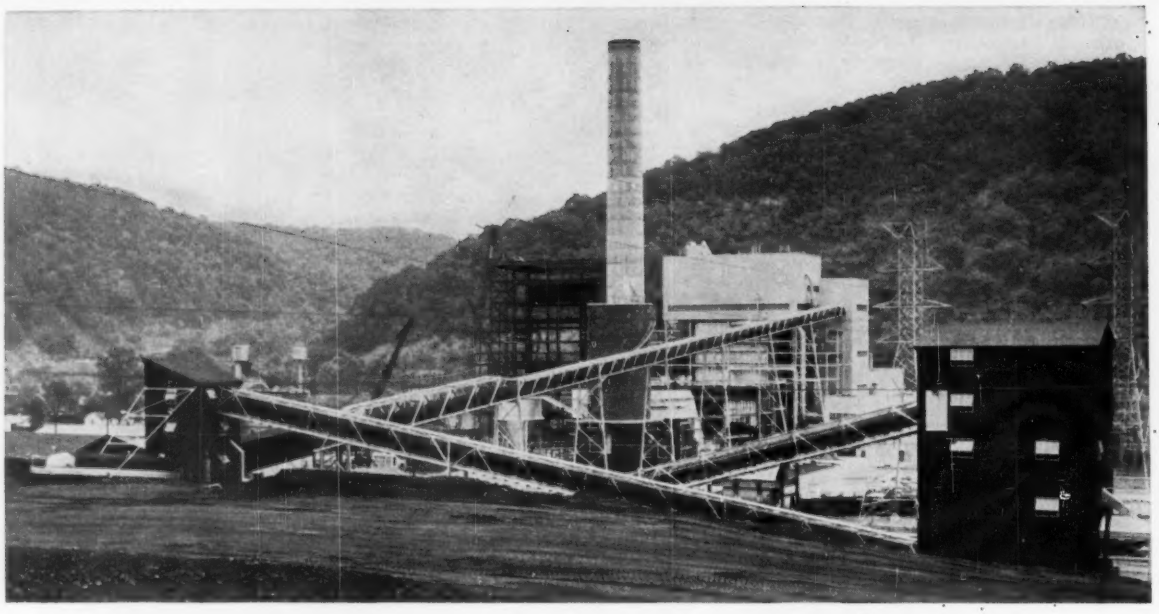


POWER HOUSE COAL HANDLING BY H&P

For dependable, low-cost handling, the West Penn Power Company *again* relies on Heyl & Patterson. At the new Armstrong Power Station, coal is unloaded by a rotary railroad car dumper and simultaneously weighed on the dumper platen by an electronic scale (Pat. Pend.). Belt conveyors then carry the coal to the Bradford Breaker and subsequently either to storage or to the Power House bunkers. While on its way, a predetermined quantity of coal is crushed and sampled. All this equipment including dumper, breaker and sampler was designed and built by Heyl & Patterson.

H & P Coal Handling Systems are carefully engineered for specific requirements and provide flexible yet economical performance. They are known for low maintenance requirements even when operating continuously. In short, THEY BEAR THE MARK OF QUALITY—based on over 70 years of experience.

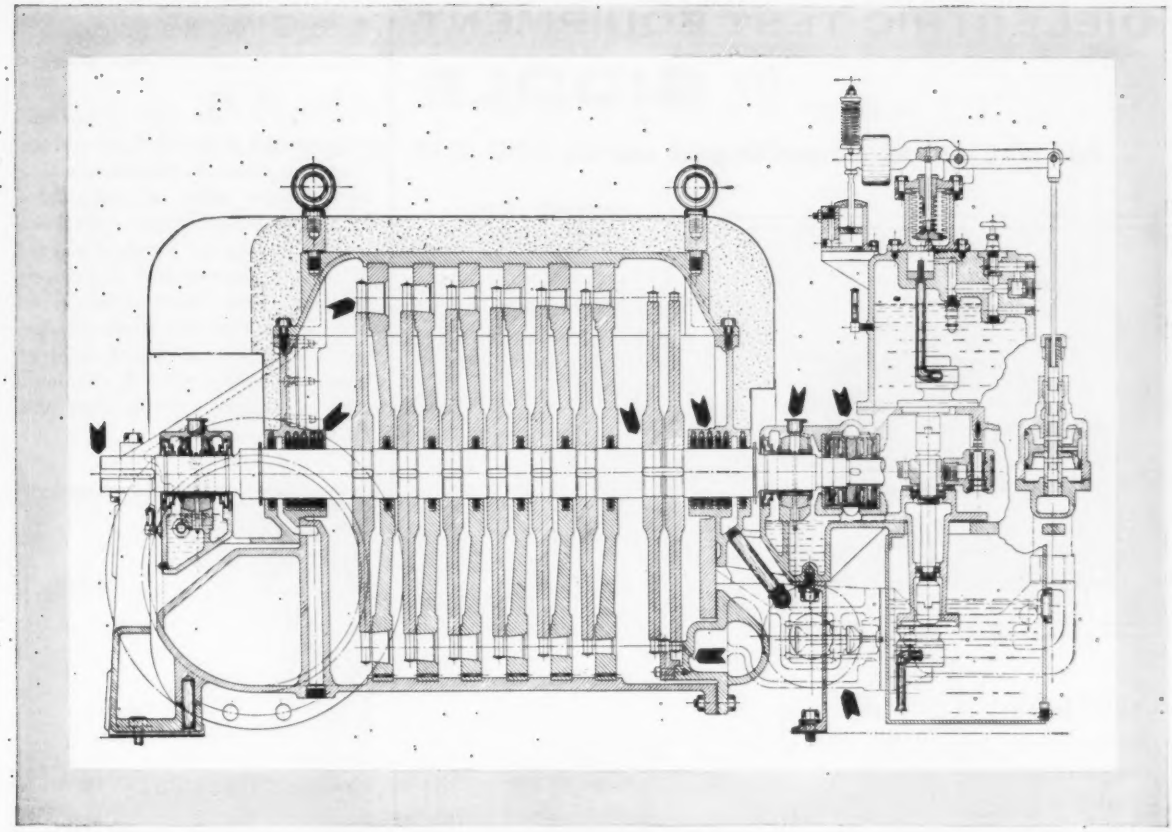
An H & P Contracting Engineer is at your disposal to assist in developing the most practical method of handling your coal out of barges or railroad cars to and from stock pile and into your bunkers.

H & P is equipped to furnish such complete installations all the way from design to erection.

When Experience Counts—
Count on Heyl & Patterson!
Since 1887

Heyl & Patterson INC.

55 FORT PITT BLVD., PITTSBURGH 22, PA., COurt 1-0750



ANOTHER INSIDE STORY OF THE UNIVERSAL ACCEPTANCE OF MURRAY MULTI-STAGE TURBINES IN THE MECHANICAL DRIVE FIELD

- Husky accurately machined shaft.
- Discs shrunk and keyed in place.
- Stainless steel nozzles and blading throughout.
- Spherical seated sleeve bearings.
- Kingsbury thrust bearing.
- Center line support.
- Carbon ring gland seals.
- Double seated balanced governor valve — stellited.
- Choice of speed governors from simple mechanical type to precision oil relay.
- Bolt type overspeed trip governor.
- Steam conditions to 600 PSIG and 750°F.
- Condensing or non-condensing.

Our nearest representative will gladly help you solve your mechanical drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

Murray
TURBINES

MURRAY IRON WORKS COMPANY • BURLINGTON, IOWA
Builders of Steam Power Equipment for Nearly a Century

DIELECTRIC TEST EQUIPMENT by BIDDLE

...for d-c tests at voltages up to 100 KV

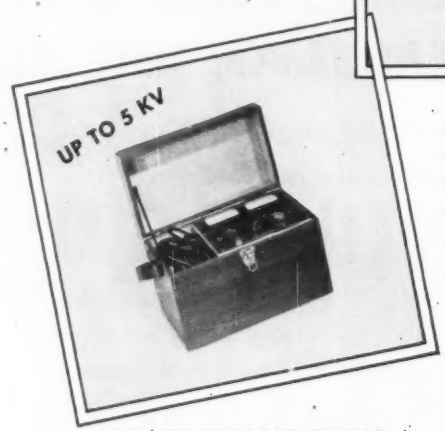
IMPORTANT FEATURES

- Well-designed provisions for utmost safety
- Simple operation and reliable performance
- Excellent output voltage regulation
- Compact, mobile design
- Facilities for voltage and leakage current measurements

IMPORTANT USES

Development—to test d-c dielectric strength of insulating materials and the adequacy of the electric design of insulation in equipment.

Production—for non-destructively detecting defects in electrical insulation.



Maintenance—and preventive maintenance—for non-destructively detecting unreliable condition of electrical insulation in new or repaired equipment.

NEW TECHNICAL BOOK

A new technical treatise by E. B. Curdts, Director of Engineering, James G. Biddle Co., contains a wealth of pertinent data for the engineer interested in insulation maintenance of electrical equipment.

Copies are available at $2.00 each. Orders should be made on your company's letterhead accompanied by check to the order of the James G. Biddle Co. Ask for Publication 22TIP.

B-810

JAMES G. BIDDLE CO.

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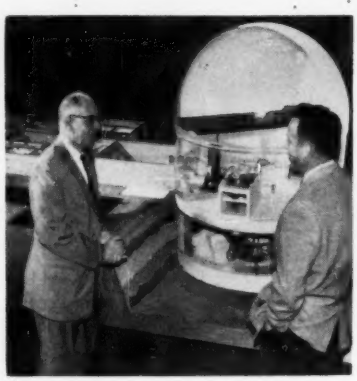
ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
LABORATORY & SCIENTIFIC EQUIPMENT

Reports from the field

Begins on page 146

table with a water inlet at one end and an outlet at the other, top picture. Discharge water is collected in a tank located under table and recirculated by a ¾-hp pump. Strips of metal two to three in. high are arranged on edge to form a cross-section of the precipitator. Then water is turned on and various vane and baffle arrangements are studied. Water is dyed blue, then sprinkled with aluminum powder, to create a readily observable pattern, bottom photo.



Plutonium enriches reactor fuel, saves money

The recycle reactor is designed to run cheaply, with plutonium-enriched fuel used instead of U-235. General Electric Co built this model of a reactor now under construction at Hanford Works. In conjunction with the test-reactor project, a pilot plant will assemble fuel elements.

Hex mesh cuts maintenance in corrosive atmospheres

Nickel-copper alloy netting for main steam lines, high-temperature duct work and boiler casing insulation can head off difficult maintenance problems. The Mobile, Ala, mill of International Paper Co, Southern Kraft

NOW . . . FORCED-DRAFT FIREBOX PACKAGES

Forced-draft Kewanee Square-Heat Package arrives on the job as a unit, ready to hook up and fire . . . complete with burner, pre-wired control panel, pre-cast refractory chamber and skids. It requires no crating, . . . no job-site insulating.

KEWANEE® SQUARE-HEAT GAS-OIL UNITS

for 15 lb. steam or 30 lb. water, 216,000 to 1,800,000 Btuh

For the first time, Kewanee offers a fire-box package boiler! The new Square-Heat Packages are forced-draft, requiring only a stub vent—no high stack. Kewanee's new combination gas-oil burner fires natural, mixed or L.P. gas . . . No. 1 or 2 fuel oil. One switch changes fuels . . . automatic changeover is available. An exclusive air distribution system pre-mixes gas and air before it enters the combustion chamber, for smoother and more efficient firing.

Along with the new burner is a new pressure-tight front flue cover dogged down by easily removed wing nuts . . . and a new, standard-equipment, wrap-around insulated jacket of heavy-gauge steel. Retained in the new units are Square-Heat's compact design, large firebox, widely spaced 3" fire tubes, large disengaging area and ample steam space.

For complete facts see your Kewanee Man or write: AMERICAN-STANDARD®, KEWANEE BOILER DIVISION, 111 Franklin Street, Kewanee, Illinois.

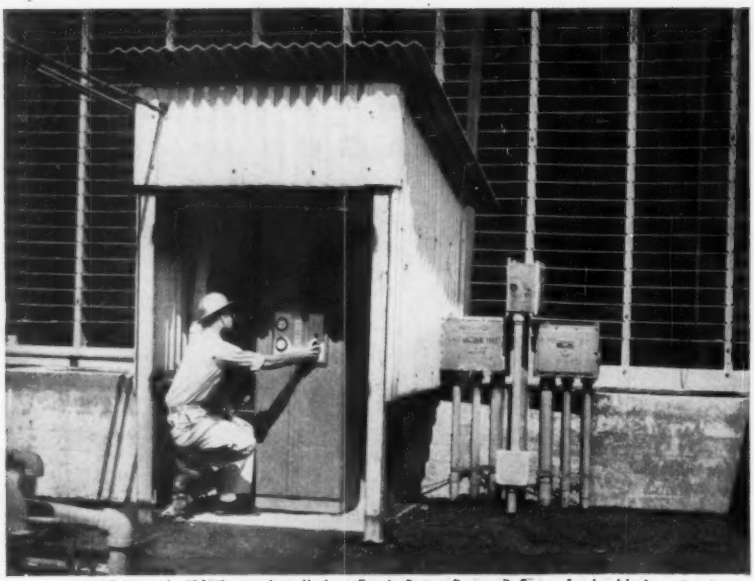
See this new Square-Heat unit among the display of Kewanee forced-draft packages at Booth 63-65-67, ASHAE Show, Philadelphia, January 26-29, 1959.

®American-Standard and Standard-® are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard Products

AMERICAN-Standard

KEWANEE BOILER DIVISION



W&T V-notch Chlorinator installed at Esso's Baton Rouge Refinery feeds chlorine at rates up to 500 lbs./24 hr. Units are available with chlorine capacities up to 2000 lbs./24 hr.

NEW W&T V-NOTCH CHLORINATORS,

used at Oil Refineries, are rugged, easy to operate and moderately priced.

Esso Standard Oil Co. has a W&T V-notch Chlorinator installed at their Baton Rouge, La., Refinery. The chlorinator, installed in a small shed open to the sun and weather, chlorinates cooling water for slime control.

This type of installation would be considered rugged service for other equipment but V-notch Chlorinators are designed for such use. They are made of materials that are completely resistant to corrosion as well as weather. They are simple to operate and to maintain. In addition, W&T V-notch Chlorinators are an attractive piece of equipment, colored green to fit into industrial color schemes.

For more information about W&T V-notch Chlorinators, send for bulletin CD-44. 76.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

ELECTRO RUST-PROOFING CORPORATION

30 MAIN STREET, BELLEVILLE 9, N. J

Reports from the field

Begins on page 146

Div, one of the world's largest paper mills, is located in a highly corrosive industrial and salt-water atmosphere near the Gulf of Mexico. The 3-twist 1-in. hex-mesh wire netting has resisted moisture, heat, acid, alkalines and sulfate fumes since first sections were installed in November, 1956.

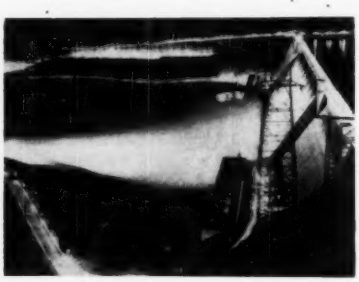
Biggest part of insulation maintenance costs on boilers and steam equipment comes from expensive scaffolding, so a long-life netting pays for its extra cost by eliminating costly repair jobs. This mesh is fabricated from International Nickel Co's *Monel* wire by Gilbert & Bennett Mfg Co.

Calendar of Events

Jan 12-14—National Assn of Corrosion Engineers, Canadian Region, eastern meeting. Montreal, P.Q. Details from NACE, 1061 M&M Bldg, Houston 2, Tex.

Jan 26-29—American Society of Heating and Air-Conditioning Engineers, Annual Meeting and Exposition. Convention Hall, Philadelphia, Pa. Details: International Exposition Co, 480 Lexington Ave, New York 17, N. Y.

Jan 26-29—Plant Maintenance & Engineering Show and Conference. Public Auditorium, Cleveland, Ohio. Details from Clapp & Poliak, Inc, 341 Madison Ave, N. Y. 17, N. Y.

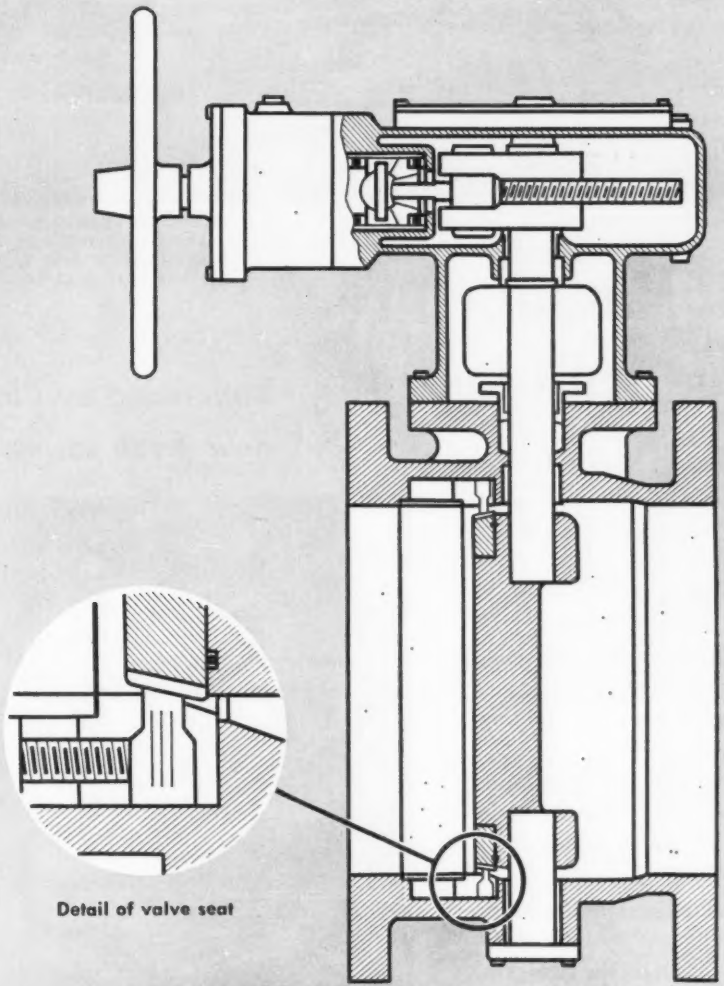


Floodlights add tourist allure to Grand Coulee's other uses

Specially designed floodlighting system now provides a spectacular color display at the Grand Coulee Dam in Washington.

(*Continued on page* 246)

Get longer life and trouble-free performance with Pelton rubber-seated butterfly valves



Detail of valve seat

Pelton rubber-seated butterfly valves are available with hydraulic cylinder, manual operator, or Pelton motor operator.

A 6-in. test valve under 50 psi with a flow corresponding to a 16 fps velocity in the adjacent 6-in. pipe was recently operated through 12,500 cycles. (10,000 with rubber seat ring downstream of valve operating shaft, 2500 with it upstream). Periodic checks at frequent intervals revealed that the valve was absolutely droptight throughout the entire test. Similar tests conducted under 125 psi demonstrated equally outstanding performance of these butterfly valves.

Manufactured in strict accordance with AWWA standards, Pelton rubber-seated butterfly valves offer the following significant advantages:

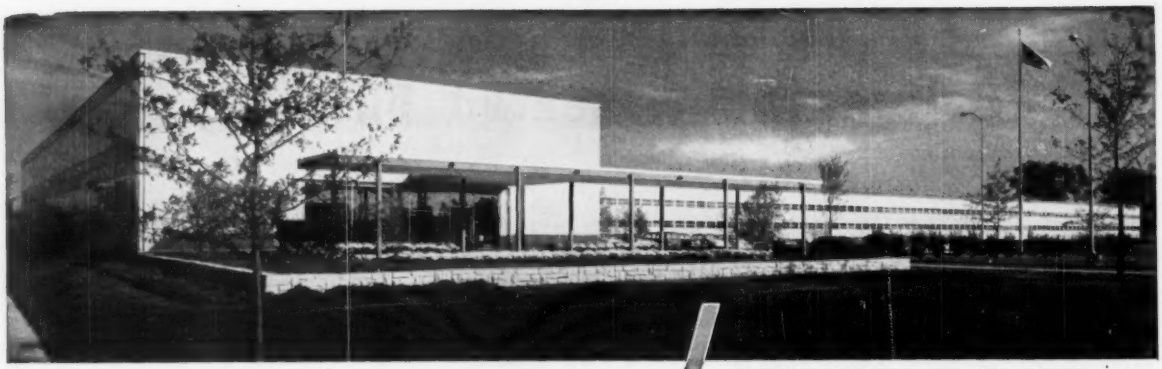
- **Compactness**
- **Ease of operation**
- **Low maintenance**
- **Greater net flow area (lower head losses than for comparable size valves)**

In addition to butterfly valves, Pelton manufactures impulse turbines, reaction type turbines, hydraulic turbine governors, spherical valves, pressure regulators, surge suppressors, waterworks valves, large centrifugal pumps, duplex strainers, dynamic balancers, etc. For descriptive illustrated bulletins, write Pelton Division (B-L-H), 2929 Nineteenth Street, San Francisco 10, Calif., or Eddystone Division (B-L-H), Philadelphia 42, Pa.

Pelton Division San Francisco, Calif.

BALDWIN • LIMA • HAMILTON

Hydraulic turbines • Valves • Governors • Centrifugal pumps



ARCHITECTS and ENGINEERS: Skidmore, Owings & Merrill
GENERAL CONTRACTORS: Chell and Anderson
HEATING and PROCESS PIPING: Wm. A. Pope Co.
AIR CONDITIONING and VENTILATION: Cicero Sheet Metal Co.

Efficient Manufacture Employee Well-being

both aided by Clarage "air" in new Avon cosmetics plant

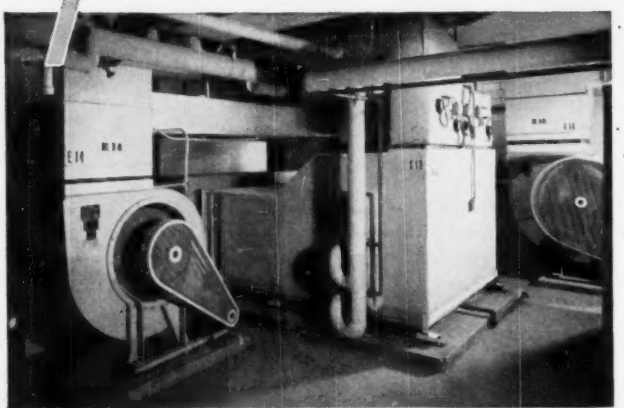
Here is much more than a thoroughly modern manufacturing facility. Here is a national sales center as well.

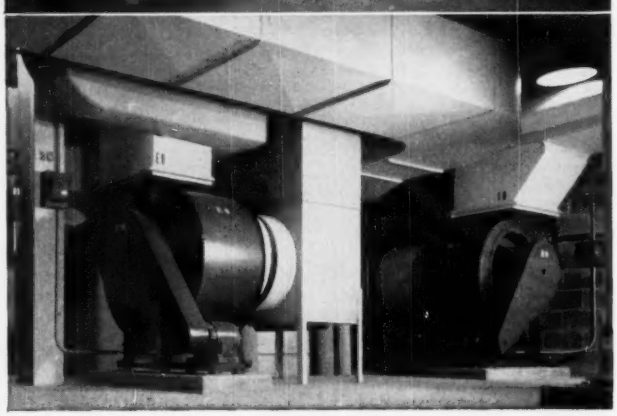
It's the new Avon Products, Inc., plant at Morton Grove, Illinois. From it flow the widely popular Avon cosmetic products. To it come members of Avon's door-to-door sales organization for training and sales meetings.

Air conditioning, thus, has a dual role to play in this structure – for employee comfort and for efficient manufacturing processes.

As for so many other noteworthy buildings, Clarage equipment was selected – some of which is shown on the right. On the job are Clarage Ready Unit ventilating sets, system fans, and Multitherm air conditioning units, including the famous Blow-Thru units pioneered and perfected by Clarage for multi-zone service.

You, too, will find it profitable to specify Clarage for your next assignments – no matter how large, how small. CLARAGE FAN COMPANY, Kalamazoo, Michigan.



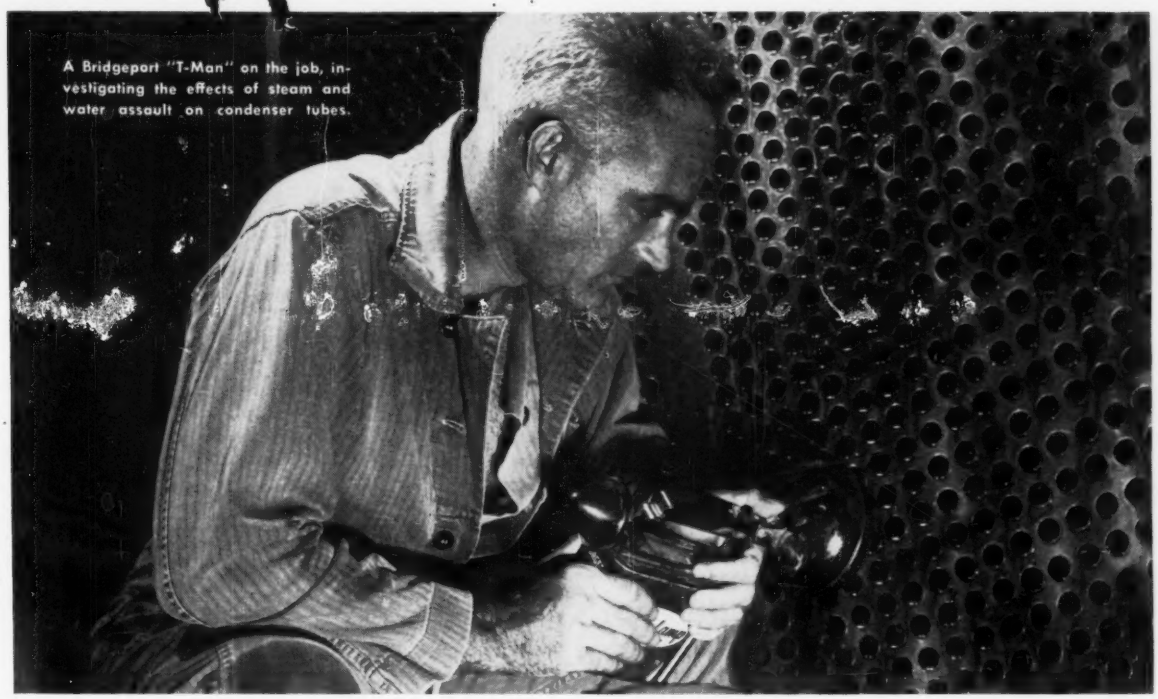


CLARAGE ... *dependable equipment for making air your servant*

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

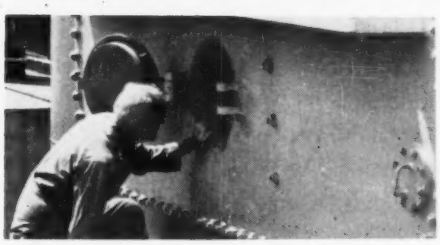
BRIDGEPORT "T-MEN"* IN ACTION

*Technical Service Men

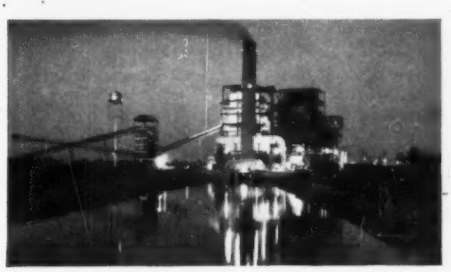


A Bridgeport "T-Man" on the job, investigating the effects of steam and water assault on condenser tubes.

The Case of the 75 Silent Witnesses



Bridgeport "T-Man" about to enter one of Carolina Power and Light's condensers to examine tubes. Bridgeport brings practical advice to the field to help in solving corrosion problems.



Carolina Power & Light Company's Louis V. Sutton plant, Wilmington, N. C., generates enough power to serve over half a million homes. Approximately 182,000,000 gallons of boiler feedwater and cooling water are circulated through the plant each day.

In the dark recesses of the mammoth Number One condenser at Carolina Power & Light Company's Louis V. Sutton Steam plant, 75 test condenser tubes of different alloys undergo constant assaults of exhaust steam and brackish cooling waters. These test tubes, manufactured by Bridgeport Brass, play an important part in Carolina Power & Light Company's test program for finding out which tubes are best suited to this type of service.

One of Bridgeport's Technical Service men recently went to the Sutton plant to observe the condition of tubes in the condenser and to study one that had been removed from service. Our "T-Man" examined tubes on the spot, and later made an analysis of a section of a tube in the Bridgeport laboratory.

A progress report was submitted to Carolina Power & Light Company on results of the laboratory analysis. This report added another practical case history to the files of Bridgeport's "T-Men," the members of our Technical Service Staff.

This type of testing and reporting is part of Bridgeport's service to its customers. Our Technical Service men work full time in the field and in the laboratory. Their research helps assure every customer that the correct tube and alloy are used to meet existing conditions. It also means maximum efficiency with Bridgeport Tubes in all types of condenser and heat exchanger applications.

Take advantage of Bridgeport's Technical Service. Call your nearest Bridgeport Sales Office today for complete service and satisfaction. Or send for a copy of the 162-page Bridgeport CONDENSER TUBE HAND BOOK. Dept. 5406.

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Specialists in Metals from Aluminum to Zirconium

In financial aid to education . . .

What Should Business Do Now?

Now that the federal government is entering the field, should business firms stop giving financial aid to our colleges and universities?

This question is now being discussed by business directors throughout the country. The discussion is prompted by the near-billion-dollar program of federal aid to education passed by Congress a few months ago. For if the federal government, with its access to billions in taxes, is assuming responsibility for the financial welfare of education, should not business get out of the way and let the government take over? This is the general way the question is being asked.

The answer is a resounding NO.

What The Federal Program Does

The new federal program makes it possible for the government to spend the imposing total of $900 million for aid to education over the next four years. There are still many loose ends in the program. But already it's quite clea. what such funds will — and will not — do to help relieve the financial plight of our colleges and universities.

First of all, the program is not going to solve any financial problems in education overnight. The program is just barely underway. So far no money has actually been allocated, and Congress has appropriated only $40 million — less than 5% of the total.

More important, there is very little in the total program which will result in direct aid to colleges and universities. The program does set up fellowships to train college teachers. But most of the aid will eventually be channeled through the states to primary and secondary schools. The main focus of the program is education for national defense — strengthening science, mathematics and foreign languages in elementary and secondary schools, together with grants for counseling, testing and research.

The one big item for higher education is a $295 million student loan program, which will help needy students pay tuition and other fees. But tuition rarely covers the full cost to the college of educating a student. So the net result could well be an additional financial strain on our institutions of higher learning.

For the three most pressing financial needs — faculty salaries, scholarship grants and new plant and equipment—colleges and universities must still rely heavily on help from the business community. And it would indeed be a major

misfortune if the recent actions of the government put a blight on this growing and substantial support to higher education.

In the last ten years, business has expanded its financial aid to education by more than four fold. In 1948, contributions were only $24 million. In 1957, such aid reached an estimated $125 million. Moreover, corporations have been putting a larger proportion of their total charitable gifts into education. In 1950, the percentage was only 17%. By pre-Sputnik 1956, the share had already increased to 34%, according to figures recently released by the Council for Financial Aid to Education.

Why Business Must Help

The most compelling reason for increasing business aid to higher education — at an even faster rate—is that our colleges and universities desperately need financial help. It is that simple. Private contributions to higher education must average at least $400 million over the next ten years if our colleges are to meet rising operating costs and raise faculty salaries to decent levels. Despite the growth in business contributions, we are still well below that goal.

If our colleges cannot solve their mounting financial difficulties through voluntary help from business firms, alumni and communities — then it is to be expected that federal aid ultimately will be mobilized in a big way. In principle, if not in dollars, the 85th Congress has paved the way. Indeed, a large federal scholarship program was squeezed out of this year's legislation only in the course of last-minute compromises. And Arthur S. Flemming, Secretary of Health, Education and Welfare, has urged that the next session of Congress restore the scholarship program.

About any federal rescue operation for higher education, two things are quite clear:

(1) **Such aid will come too late to prevent irreparable harm resulting from the current shortage of funds.** The need for help is urgent and immediate.

(2) **With federal taxes taking over half of all corporate income, any federal program in the end will be financed in large part by the business community.**

An Opportunity

So, viewed narrowly, it is in the selfish interest of business firms to aid our colleges and universities now, rather than wait and be forced to pay later on. By doing so, they ensure that business will have a continuing supply of well-trained graduates. They take advantage of the tax laws for charitable contributions which mean the government in effect assumes more than half the cost of business aid to education. And they win gratitude for a voluntary and generous act.

Viewed in the broad public interest, the business community has an opportunity to perform a financial rescue mission in education which could well be the key to successful survival, not only of our present system of higher education, but also of the nation itself.

As previous editorials in this series have pointed out, a very small share of the net income of business firms — about 1% — would do the job. Certainly business must not be distracted from this opportunity by the new venture of the federal government in financial aid to education.

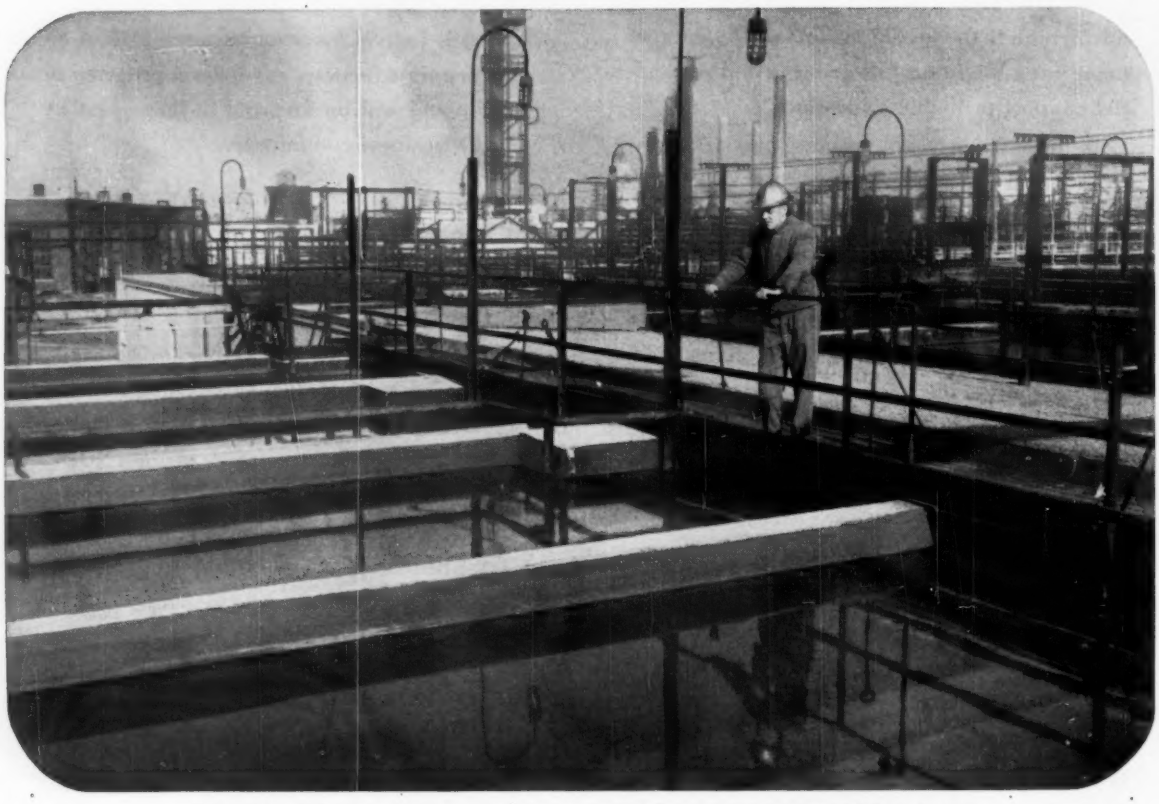
This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

ION EXCHANGE RESINS for water conditioning



This open-tank softener has been in continuous service since 1950 using its original AMBERLITE IR-120 resin.

AMBERLITE IR-120 in use over 7 years at oil refinery has treated 3,000,000 gallons of water per cubic foot of resin . . . shows no significant change in softening capacity.

That's the outstanding record of the AMBERLITE IR-120 ion exchange resin in use at the Gulf Oil Corporation's refinery in Philadelphia, Pa.

This refinery can produce 3,000,000 pounds of 200 and 680 psi steam every hour for electrical power generation, heat exchange and process use. All the water used is taken from the Schuylkill River and, after preliminary treatment, is conditioned to remove all calcium and magnesium hardness. AMBERLITE IR-120, a strongly acidic cation exchange resin operating in the sodium cycle, is used effectively and economically in the refinery's open bed, gravity-feed softeners to condition 600,000 gallons of water per hour to less than 1 ppm. of hardness.

The AMBERLITE IR-120 at the Gulf Oil Corporation's Philadelphia refinery has been in constant use since 1950 without significant change in capacity or loss of resin—and each cubic foot of resin has treated well in excess of 3,000,000 gallons of water.

While there are many installations which have given such prolonged service, the durability of ion exchange resins is dependent upon the nature of the influent water supply and operating conditions. Engineering companies specializing in water treatment are qualified by experience to give you recommendations on how AMBERLITE ion exchange resins can best serve your specific needs.

Whether you need softened, deionized, dealkalized or deacidified water, ion exchange provides a practical and effective answer to your water conditioning problems. Write for our booklet "If You Use Water" for full information about AMBERLITE resins.

AMBERLITE is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.

Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

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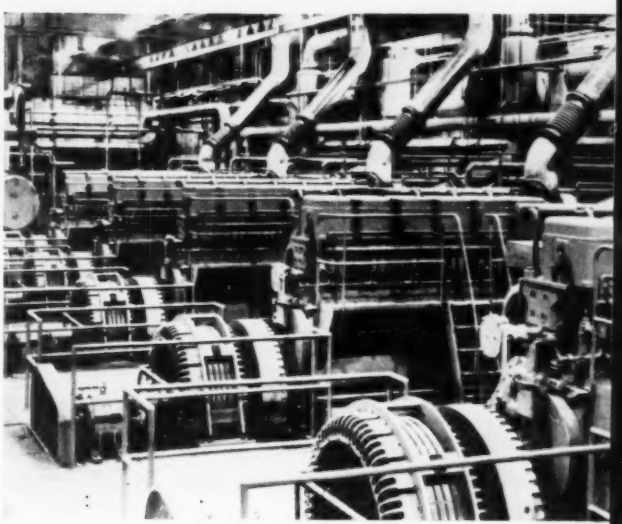
(official U.S. Air Force photo)

NORDBERG ENGINES help power SAGE System Direction Centers of the Air Defense Command

"Master-minding" the tactical operation of U.S. Air Force interceptors like this F-102 jet is an amazing electronic air defense system called SAGE . . . *Semi-Automatic Ground Environment.* By analyzing a variety of air surveillance information which is received from a vast network of facilities and fed into electronic digital computers located at its Direction Centers, the SAGE System computes the speed, altitude, and direction of planes in flight to facilitate identification. A picture of the air and defense situation is displayed so clearly that Air Force personnel can quickly decide when and where to intercept, should aircraft be identified as suspect. The system also monitors the deployment of selected air defense weapons.

The Direction Center computing and display equipment relies on station-generated electric power. To help assure adequate power at all times, Nordberg Diesels have been installed in several Direction Centers.

Nordberg Mfg. Co., Milwaukee 1, Wisconsin



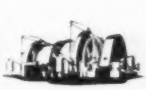
Nordberg four-cycle diesels installed in one of the SAGE system centers, generating electric power for the electronic computers, communications equipment, etc. Each of the Nordberg supercharged 6-cylinder engines is rated 930 hp at 450 rpm and is monitored electronically.

NORDBERG

© 1958, Nordberg Mfg. Co.

P658

SYMONS® CRUSHERS AND SCREENS



MINE HOISTS

GRINDING MILLS—KILNS AND PROCESS MACHINERY

RAILWAY MAINTENANCE EQUIPMENT

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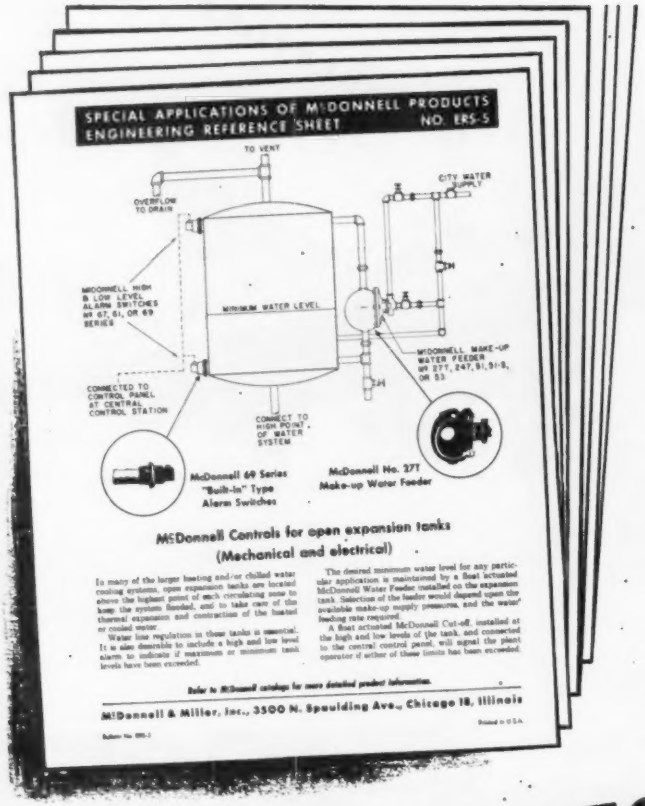
SPECIAL APPLICATIONS OF McDONNELL PRODUCTS
ENGINEERING REFERENCE SHEET NO. ERS-5

TO VENT
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OVERFLOW TO DRAIN
McDONNELL HIGH & LOW LEVEL ALARM SWITCHES No. 67, 61, OR 69 SERIES
MINIMUM WATER LEVEL
McDONNELL MAKE-UP WATER FEEDER No. 277, 247, 51, 51-S, OR 53
CONNECTED TO CONTROL PANEL AT CENTRAL CONTROL STATION
CONNECT TO HIGH POINT OF WATER SYSTEM
McDonnell 69 Series "Built-In" Type Alarm Switches
McDonnell No. 27T Make-up Water Feeder

McDonnell Controls for open expansion tanks
(Mechanical and electrical)

In many of the larger heating and/or chilled water cooling systems, open expansion tanks are located above the highest point of such circulating zone to keep the system flooded, and to take care of the thermal expansion and contraction of the heated or cooled water.

Water line regulation in these tanks is essential. It is also desirable to include a high and low level alarm to indicate if maximum or minimum tank levels have been exceeded.

The desired minimum water level for any particular application is maintained by a float actuated McDonnell Water Feeder installed on the expansion tank. Selection of the feeder would depend upon the available make-up supply pressures, and the water feeding rate required.

A float actuated McDonnell Cut-off, installed at the high and low levels of the tank, and connected to the central control panel, will signal the plant operator if either of these limits has been exceeded.

Refer to McDonnell catalogs for more detailed product information.

McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago 18, Illinois

Printed in U.S.A.

Bulletin No. ERS-5

NEW DATA SHEETS

—cover special problems solved by McDonnell products

These recently published Engineering Reference Sheets explain the interesting ways in which engineers are today using McDonnell products to step up efficiency and provide safety in connection with equipment such as:

- Expansion and compression tanks
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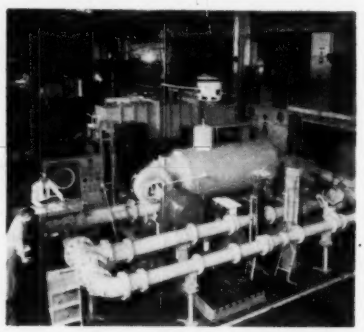
Reports from the field

Begins on page 146

A total of 742 wide-beam 1500-w floodlights in white, yellow, red, blue and green are used to illuminate dam's 350-ft-high central spillway. Lights provide an uninterrupted 30-minute display with a new color change every 12½ sec. Waterfall is half as wide and twice as high as Niagara Falls.

The 90x20-ft floodlight bank takes 1250 kw. All electrical equipment was supplied by General Electric Co.



Small pump-turbine is model for 12 full-scale units

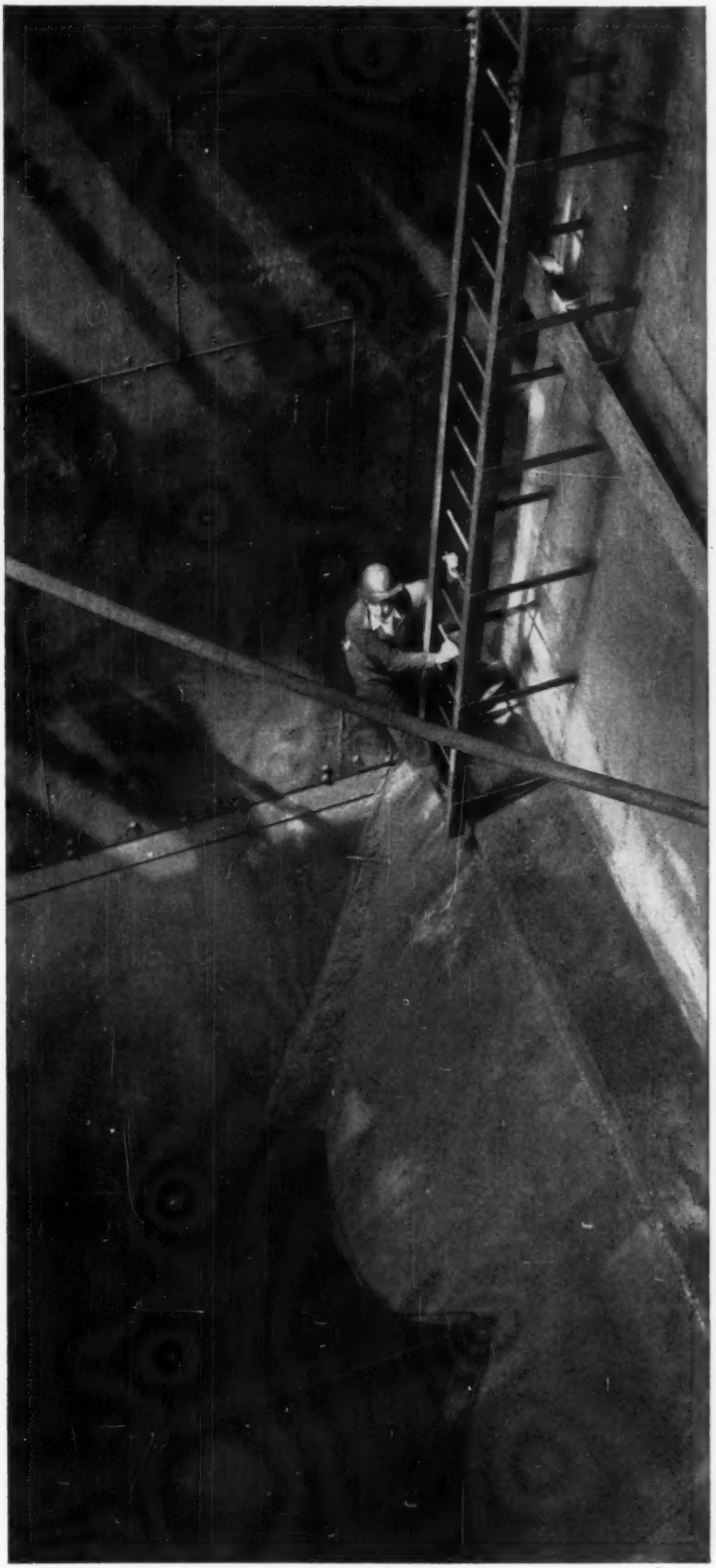
Model reversible pump-turbine is being lab-tested in connection with design and construction of a dozen full-size units for New York State Power Authority's Tuscarora plant.

The big pump-turbines, each rated to pump 3400 cu ft per sec against an 85-ft head, will be 14 times larger. Units are being built jointly by Allis-Chalmers Mfg Co and S Morgan Smith Co to insure quick delivery.

Sea-water conversion plant dedicated at Aruba

"You are the first large community in history to get all of its drinking water from the ocean; the eyes of many water-hungry nations will be watching to see if this brings the

Coal hoppers, chutes and liners are among the many applications in which USS "T-1" Steel has greatly increased service life.



How to **beef-up** your equipment without adding fat

Build it stronger, tougher and lighter with USS "T-1" Steel plates. This remarkable steel was developed especially to meet the need for bigger machines and stronger, more durable equipment, built larger but with lighter components.

"T-1" Steel's greater strength reduces weight. Furnished quenched and tempered to 100,000 psi minimum yield strength, USS "T-1" Steel plates permit designers to reduce the thickness of steel used for water turbine cases, penstocks, transformers and many supporting structures. Weight reductions of 25% to 50% are possible. This in turn cuts freight and welding costs and reduces foundation requirements. USS "T-1" Steel plates can still be furnished to 90,000 psi min. yield strength and 105,000 psi min. tensile strength to meet the requirements of ASME Code 1204-3.

"T-1" Steel lengthens service life. For maximum resistance to impact abrasion, USS "T-1" Steel is furnished quenched and tempered to 321 minimum Brinell. It is recommended for applications such as coal chutes, hoppers, pulverizer feed pipes, exhaust pipes and liners for ash collectors. Users report increases in service life up to 100% or more.

"T-1" Steel is weldable. It's unusual that a steel so strong and durable can be readily welded in the field without pre- or post-heating. This characteristic permits on-the-spot fabrication at minimum cost.

Write for free "T-1" booklet which contains design and application information, as well as helpful hints on fabrication of this versatile constructional alloy steel. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS and "T-1" are registered trademarks

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Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

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USS

STEAM TURBINE PERFORMANCE and ECONOMICS

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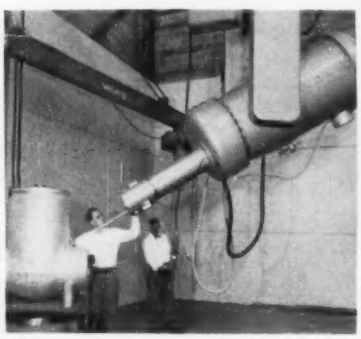
Reports from the field

Begins on page 146

prosperity we predict and expect," Finance Secretary J E Yrausquin of the Netherland Antilles told the 55,000 inhabitants of Aruba, a small semiarid Dutch island off the coast of Venezuela.

World's largest single installation for converting sea water to fresh, the $10,000,000 plant was designed and built by Singmaster & Breyer. It has a capacity of 2,700,000 gpd of fresh water.

An arm of the Caribbean sea is shown at far right, evaporators and four water-storage tanks are at center front, steam power plant is at left front. Small obsolete conversion plant is shown at rear.



Nondestructive testing gets a shot in the arm

Two-million electron volt Van de Graaff radiographic X-ray generator, the first of its type to be installed in the U.S., graces American Chain & Cable Co's ACCO Steel Casting and R-P&C Valve Div. Unit is installed in a building with high-density concrete walls, 48-in. thick for the section housing the X-ray generator and 24-in. thick for the part enclosing the gamma-ray source of Cobalt 60.

Castings are hauled in by lift truck over concrete beds to insure smooth delivery. Readings are taken at intervals during a maximum exposure of 15 minutes for 10-in.-thick steel castings. In photo, above, casting is in place and ready for inspection. Focal distance from tube's end to casting body is being measured.

New installation should satisfy demand for highest-quality castings and pressure seals. It works eight times faster than previous methods used by the company.

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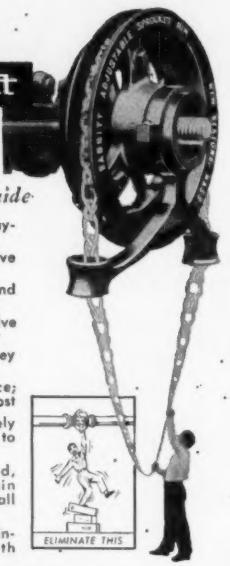

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New surgical techniques, diagnostic methods, and an informed public are important reasons for these gains.

More and more people have learned that many cancers are curable if detected in time. And, sensibly, more and more people have formed the life-saving habit of an annual health checkup. They know it's living insurance against cancer!

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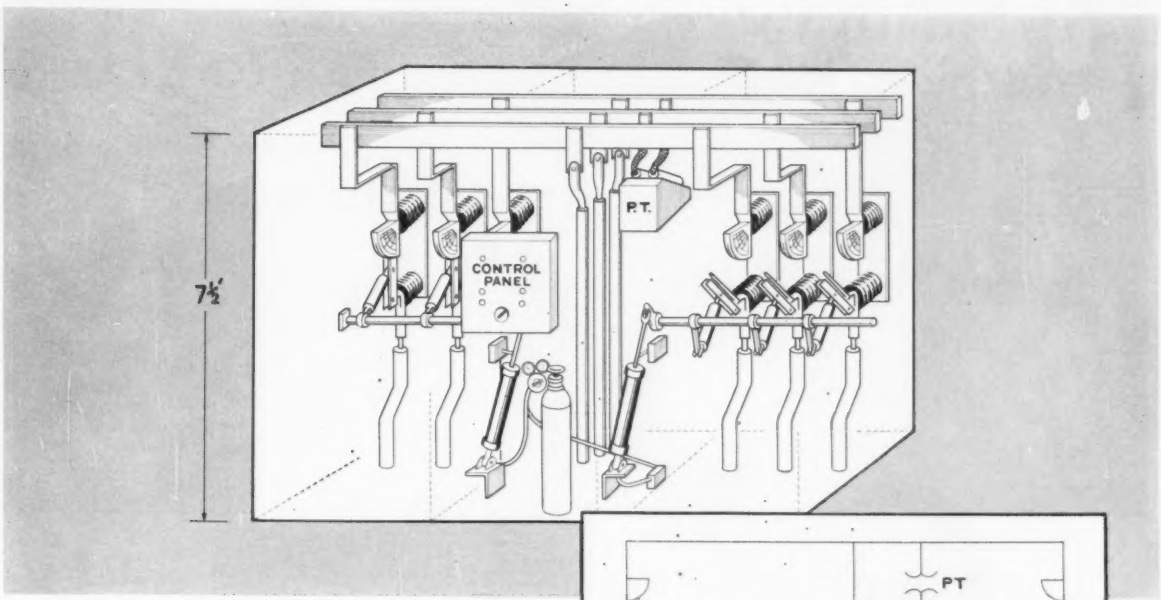
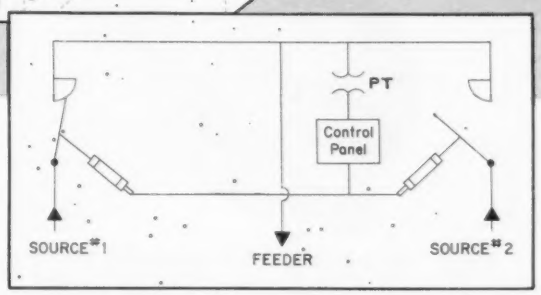
R&IE POWER SWITCHING CENTERS





Three-cubicle automatic throwover system! The control circuitry is contained within the control box and powered through the potential transformer. It senses the failure of the preferred voltage source, automatically disconnects it, and then closes into the second, or emergency, source. A 3-position selector switch on the control panel allows override of automatic control by either manual-pneumatic actuation of the power switches with poppet valves located on the outside of each cubicle or by an emergency handle which actuates the switches through direct chain drives. Lights on the panel indicate control voltage availability, occurrence of throwover, and positions of switches.

AUTOMATIC POWER CONTROL

Simple, lower-cost automatic throwover for assured service continuity ...now available with R&IE's Electro-Pneumatic Power Switching Centers

For continuous industrial processes, where shutdowns due to loss of voltage are intolerable, an R&IE Power Switching Center with automatic throwover can serve you as an ever-vigilant switchman, ready to go into action whenever service continuity is endangered. Its operation, simple and straightforward, consists of constantly monitoring load circuit voltage and, upon loss of it, automatically switching to a substitute source. Electrically controlled, with pneumatically actuated power switches, this system can provide you with dependable automatic power control at a cost significantly lower than comparable systems using motor or hydraulic actuation. Energy requirements of the pneumatic system are extremely low.

The force used to actuate the HPL-C power switches is provided by double-acting, heavy duty air motors. Pneumatic pressure is provided by a standard nitrogen cylinder or by dry compressed air from the plant system. One cylinder contains sufficient pressure for up to 500 complete operations. The pneumatic system, including nitrogen cylinder, air motors, and all controls, is mounted in a separate metal enclosed compartment. Provision is made for disengaging the air motor from the switch linkage to test the pneumatic system.

Power switching centers with automatic throwover can be supplied with any number of individually enclosed outgoing feeders up to 2000 amp. And additional feeders can be added —easily and economically—at any time. Each feeder can be controlled by a directly or remotely operated HPL-C power switch rated for safe closing into 3-phase faults of up to 250,000 kva—up to 1,000,000 kva with current limiting fuses.

Only one potential transformer is required in the load circuit for adequate sensing and power for the simple automatic throwover, manual return system shown. In addition to this and other automatic throwover systems, R&IE Power Switching Centers, in ratings from 4.8 through 14.4 kv, can be equipped with automatic controls for overload protection, operation from ground fault relaying equipment, or other special condition. For complete information, contact your nearest I-T-E sales office or write R&IE Equipment Division, Greensburg, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

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for users of underground piping systems...

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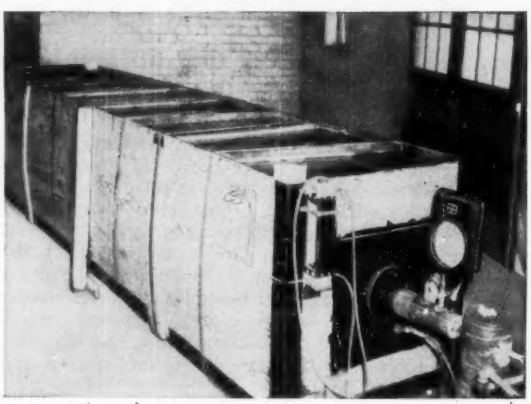

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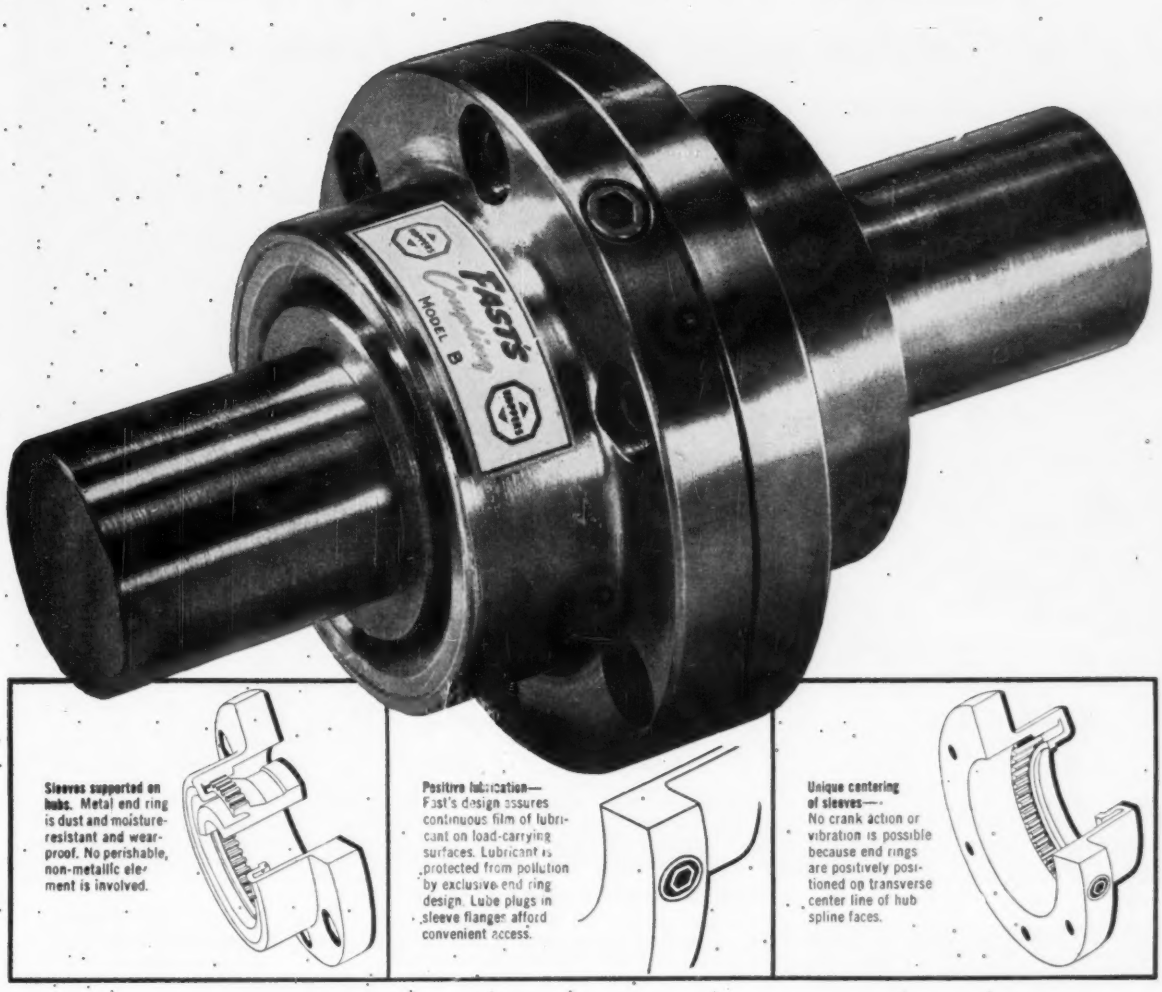

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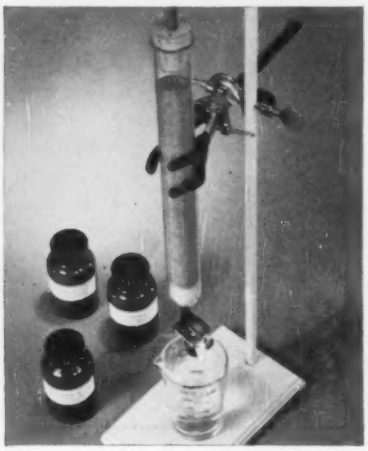
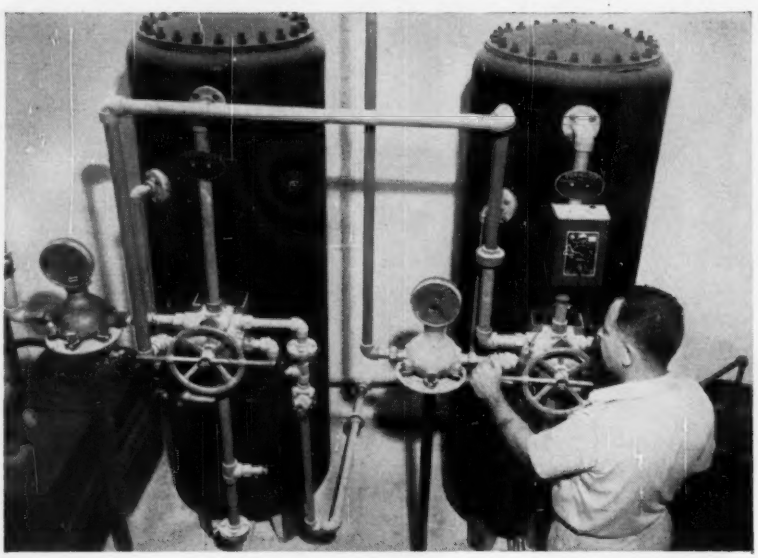


stand, clamps, tubing, stoppers and beakers. The tube will hold sufficient Permutit Q ion exchange resin to remove 20 to 25 grains of hardness.

This simple set-up is used for demonstrating ion exchange processes such as softening, dealkalizing or demineralizing water and for experiments in removal of impurities from process solutions and separation of metals from leached ores or waste liquids.

MBD-6A mixed bed demineralizer

The MBD-6A unit (6″ diam.) contains a mixture of Permutit Q cation exchange resin and Permutit S anion exchange resin. It will demineralize 1 to 2 gpm of water to a low total solids, low CO_2 and low silica content. Refills containing pre-mixed resin are available. Each refill has a capacity of approx. 1500 grains total electrolytes as $CaCO_3$. When the unit is exhausted, the fill may be discarded or regenerated and re-used.



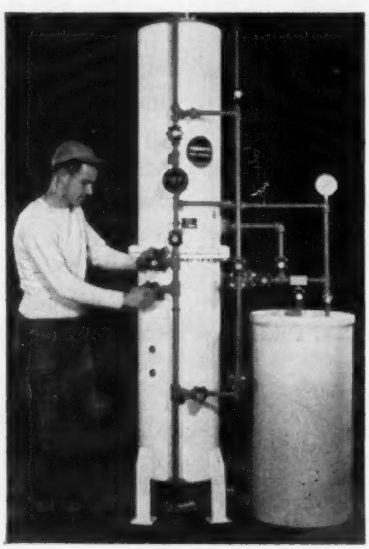
A conductivity cell is mounted in the outlet line to be used with a conductivity meter for measuring the electrolyte content of the effluent and thus indicating when the resin bed is exhausted.

Standard equipment includes the MBD-6A with initial fill, faucet adapter and hose and conductivity cell. Optional equipment: conductivity meter, resin refills and an auxiliary tube for regenerating the resins.

MBD-15 mixed bed demineralizer

This compact unit will demineralize 6 to 7½ gpm of water to an average conductivity of 0.15 micromhos (approx. 6,000,000 ohms specific resistance per cm or 0.05 ppm total electrolyte content). CO_2 will be reduced to 0.1 ppm and SiO_2 to about 0.1 ppm.

Capacity of the MBD-15 between regenerations is approx. 20,000 grains total electrolytes. For example, it will demineralize



3420 gallons of water containing 100 ppm total electrolytes or 1710 gallons containing 200 ppm total electrolytes. When the unit is exhausted, the resin bed can readily be regenerated without removing the resins from the tank. The plastic regenerating tank is used for both regenerants.

The MBD-15 is supplied piped and partially assembled and requires connecting together only 3 flanges other than the connections to influent, effluent and waste lines.

16″, 24″ and 30″ diam. single bed units

(see photo above)

Diameter of unit	16″	24″	30″
Approx. flow rate (gpm)	10	20	30

Construction of these "package" units is of the same heavy-weight materials used for Permutit's large custom-designed units and includes rugged PVC plastic interior piping and plastic strainers, full 3/16″ thick rubber lining steam-cured and vulcanized to the heavy gauge steel shell. The entire lining is spark-tested at 25,000 volts. Exterior piping is high strength plastic.

Standard equipment includes a rubber-lined Permutit multiport control valve for each unit, acid pump, corrosion-proof plastic tank for cation regenerant and steel tank for anion regenerant. All parts are normally kept in stock for immediate shipment and are described in standard drawings.

° ° °

For complete information, write to The Permutit Company, Dept. PO-12, 50 West 44th St., New York 36, N. Y. or Permutit Company of Canada, Ltd., Toronto 1, Ont.

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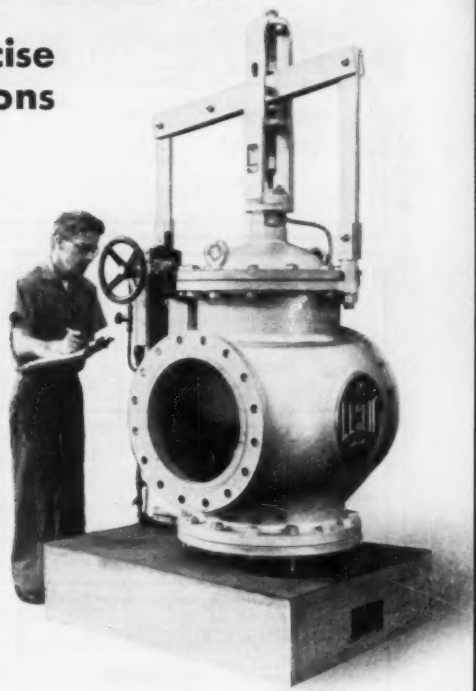

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—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publishers to secure more advertisers and—more advertisers mean more information on more products or better service—more value—to YOU.

SEARCHLIGHT SECTION

Classified Advertising

EMPLOYMENT: BUSINESS: **"OPPORTUNITIES"** EQUIPMENT USED OR RESALE

DISPLAYED —RATES— UNDISPLAYED

The advertising rate is $20.50 per inch for Equipment & Business Opportunity advertising appearing on other than a contract basis. Contract rates quoted on request.

Employment Opportunities—$47.40 per inch, subject to Agency commission.

An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

$2.10 per line, minimum 3 lines. To figure advance payment count 5 average words as a line. Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Positions Wanted undisplayed advertising rate is one-half of above rate payable in advance.

Box Numbers—count as one line.

Send New Ads to Class. Adv. of Power, P.O. Box 12, N.Y. 36, for January Issue closing December 10th.

A COMPLETE SOURCE FOR POWER EQUIPMENT

MOTORS — DC
230 Volt Variable Speed

H.P.	Make	Type	Speed
125/250		CDM-1661Z	
new	G.E.		400/1200
115	West.	SK-190	600/1200
100/125	Rel.	1050T	500/1500
75/100	Cr. Wh.		500/1500
75	Rel.	T1050T	300/1200

MOTORS—DC
500 Volts

H.P.	Make	Type	Speed
3300	West.	Mill	140/210
2250	West.		90/210
1500	West.	T.E.	600
600	Al. Chal.		300/600
150	West.	Mill	360/1200

NEW
100 KW DIESEL SETS
100 kw, 120/240 Volts DC Delco Generator driven by 152 H.P. 1200 rpm 8 cylinder Model GDB-8 Superior Diesel Engine.

SLIP RING MOTORS
3 ph—60 cy—220 or 440 Volts (*2300 Volts or higher)

H.P.	Make	Type	Speed
5500	*G.E.	MT-30	240
1500	*West.	HF-1227	252
1500	*G.E.	MT-16	443
1000	*G.E.	MT-575S	1185
500	*Al. Chal.		293
300	*West.	CW	1150

AC MOTORS
3 ph—60 cy—220 or 440 Volts 2300 Volts or higher

H.P.	Make	Type	Speed
4000 new	*West.	Syn.	1200
2000	*Ideal	Tot. enc.	900
1500 new	*West.	Syn.	450
920 new	G.E.	Syn.	300
800	*G.E.	K-6346SY	1770
800	*West.	CS4-34C15	1770
500	*West.	Syn.	1800

MOTOR-GENERATOR SETS
3500 KW, 514 RPM, 350/700 VDC, 13800/6900/4160 VAC, Allis-Chalmers (2)
1250 KW, 450 RPM, 250 VDC, 2300/4160 VAC
500 KW, 900 RPM, 250 VDC, 2300/4160 VAC, General Electric Generator
200 KW, 1200 RPM, 250 VDC 2300/4000 VAC, Westinghouse Generator

TRANSFORMERS
2500 KVA, 13800 Pri. 2300 Sec, 3/60 General Electric
1500 KVA, 24000 Pri, 480 Sec, 1/60 Westinghouse, SL, OISC. (6)

CIRCUIT BREAKERS
6000 Amp, G.E. 3 Pole, Magnetic
4000 Amp, G.E., 2 Pole, Magnetic
3000 Amp, G.E., 3 Pole, Magnetic
1600 Amp, G.E., 3 Pole, Magnetic

WESTINGHOUSE FREQUENCY CHANGER
1250 KVA, 800 Volt, 1 Phase, 960 Cycle, 1900 RPM Generator driven by a 1875 HP., 2300 Volt, 3 Phase, 60 Cycle Syn. Motor. Modern water-cooled set, complete with Controls, Furnaces, (2) Exciters, mounted on steel base.

DUQUESNE ELECTRIC & MFG. CO.
6401 BROAD ST., PITTSBURGH 6, PENNA. PHONE: MONTROSE 1-5800

FOR SALE—EXCEPTIONAL BARGAINS
Diesel Generator Units, 200 KW-1500 KW — Turbo Generators, 500 KW-10,000 KW
Motor Generator Sets—Rotary Converters—Synchronous Condensers—
Frequency Changers—Transformers—Pumps, Boilers.
UTILITIES MACHINERY CORPORATION
1965 East Sixth St., Cleveland 14, Ohio • PHONES: CHerry 1-0210 & CH 1-4070

FOR SALE—GENERATOR SETS
1—485 KW Diesel, 480 V AC 3/60, 360 RPM, G.M. Complete, Excellent condition.
1—1000 KVA Hydro Unit, 2200 V AC 3/60 360 RPM, Vertical, 60' hd, Complete.
SUNDFELT EQUIPMENT COMPANY, INC.
802 E. Anaheim, Wilmington, Calif.

WANTED
Complete power plants, turbo generators, Boilers, Condensers, Engine generators, Processing Plants and equipment.
PAUL OBERMAN
1910 Delmar St. Louis, Mo.

WE PAY $ CASH $ FOR
Electric Motors • Starters • Transformers
Circuit Breakers—Electric Supplies
ALLIED ELECTRIC CO.
710 N. MAIN ST., MEMPHIS, TENN.
BOX 1838—PHONE JA 7-1681

GET CASH NOW
for your new surplus motors, controls and transformers!
AVAILABLE: NEW MOTORS
Over 5,000 new motors, in stock, from ½ HP to 200 HP. Special low prices.

Write, wire or phone collect!
AJAX ELECTRIC MOTOR CORP.
P.O. Box 262, Rochester, N.Y.
Long Distance Phone LD. 132

POWER EQUIPMENT
300 KW G.E. Non-C Turbo Generator 3/60/480-150% 5-10% BP 3600 RPM
2000 KW GE N.C. Ext. Turbo-Gen. 480V, 600% 650° 150% Ext. 30%B.P.
45000% Combustion Engineering BOILER 450% 750°TT oil fired
509 HP Babcock & Wilcox BOILERS (3) 200% sect. header, oil fired
BREW, WOLTMAN & CO., INC.
50 Church St., New York 7, N. Y.

1500 HP D.C. MOTORS
1500 HP—525 volts D.C.—600 R.P.M.—NEW—2-bearing continuous duty motors—manufactured by Westinghouse. In original crates. From Navy Destroyer Escort. SPECIFICATIONS: 2-bearing 1500 HP—525 volts DC—2270 amps—600 RPM—ambient temperature 40C—class B insulation—2-bearing pedestal sleeve type—shunt wound—efficiency 94.23% ONLY 6 AVAILABLE—BUY NOW AND SAVE. Suitable for steel mill drive—offshore oil rigs—rolling mill drive—dredge pump applications.
THE BOSTON METALS CO.
315 E. Baltimore St. Baltimore 2, Md.
ELGIN 5-5050 LEXINGTON 9-1900

ELECTRICAL POWER EQUIPMENT

A. C. MOTORS—3 ph. 60 Cy.

SLIP RING

Qu.	HP	Make	Type	Volts	Speed
1	1750	G.E.	M-579B8	4800/2400	1800
1	1500	G.E.	MT-6	6600	1187
1	800	Whse.	CW	550	1776
1	700	Al. Ch.	D.P.	2300	500
1	600	Whse.	CW-432D-15	440	1778
1	500	G.E.	MT-412	2200	439
1	500	Whse.	CW	550	350
1	350	Cr. Wh.	8IZE-718R	203/406	1763
1	350	G.E.	IM-17A	440/2200	720
1	350	Whse.	CW-1039C	440	720
1	250	G.E.	MT-424Y	4000	257
1	250	Cr. Wh.	SIZE-290	2300	350
1	250	A.C.		550	600
1	250	G.E.	MT-563Y	440	875
1	250	Whse.	CW-1010	2200	435
1	200	Whse.	CW-874D	220	885
1	200	G.E.	IE-13B	220	1760
1	200	G.E.	IM	2200	580
2	200	G.E.	IM	2200	435
2	200	Whse.	CW-890	2300	1775

SQUIRREL CAGE

1	800	G.E.	KT-573	2200	1180
1	500	G.E.	FT-539AY	2300	3600
1	550	Whse.	CS-1115	2300	900
4	500	Whse.	CS-1216	2200	500
3	500	G.E.	KF	2300	3600
2	450	Whse.	CS-1420	2300/4150	354
2	400	Whse.	CS-7151-610H	6600/1600	3565
1	400	G.E.	LK	2200	500
1	300	Whse.	CS-1002	2300	600
1	200	Whse.	CS-963H	2300	1175/878
1	200	G.E.	KT-557	440	1800
2	200	Whse.	CS-855S	220/440	1754
1	150	G.E.	CS	440	530

SYNCHRONOUS

1	7000	G.E.	ATI	2240/6600	600
1	4350	C.W.	3501-SL	13800/6900	514
1	3500	G.E.	TS-6438P	2300/4000	360
2	1750	G.E.	ATI	2300	3600
1	1750	G.E.	TS	2300	900

M-G SETS—3 PH. 60 CY.

Qu.	K.W.	Make	RPM	DC Volts	AC Volts
2	2100/1750	G.E.	514	250/350	2300/4600
1	2000	G.E.	514	660	2300/4600
1	1500	G.E.	720	600	6600/13200
1	1500	G.E.	600	600	2300/4150
1	1000	G.E.	900	260	6600
1	1000	G.E.	720	600	6600/13200
1	750	G.E.	720	275	6600/13200
1	500	Whse.	900	125/250	440
1	350	G.E.	900	125	440/2300/4160
2	300	G.E.	1200	250	2300
1	250	Whse	1200	275	2300
1	200	El. Mfg	1200	250	2300/4600
1	300	Whse.	1200	600	2300
1	200	Whse.		550	2360
1	200	G.E.	1200	250	550/3300
1	200	Cr. Wh.	1200	250	440
1	150	Whse.	1200	275	2300
1	100	G.E.	1200	250	4160/2400

TURBO GENERATORS

Qu.	KW	Make	Desc.
1	7500	Whse.	650# condensing, 125# auto extraction, 6900
1	5000	G.E.	400# surface condenser 2400/4150 volts.
1	4000	G.E.	400# surface condenser 2400/4150 volts.

TRANSFORMERS

Qu.	KVA	Make	Type	PH.	Voltages
3	3333	Whse.	OISC	1	13800x2300
3	1000	G.E.	OISC	1	13800x460
2	750	G.E.	FUR	1	4800x35/55
3	500	KUHL	OISC	1	13600x6000
1	225	Marcus	Air	3 auto	208/220
2	160	G.E.	OISC	1	32900x2400/4160Y
3	100	Whse.	OISC	1	4600x460/230/115

FREQUENCY CHANGER SETS

Qu.	KW	Make	Freq.	Voltage
3	6750	G.E.	60/25/60	13200/13200
1	5000	G.E.	60/50/60	11000/6600
2	2500	G.E.	25 cy/62.5	2300/2300
1	500	Al. Ch.	25/60	11000/2300
1	200	G.E.	60/3000	440/880

COMBINATION MILL DRIVES—
D.C. MOTORS WITH M.G. SETS & CONTROLS
PACKAGE DRIVES IN STOCK

1—2250 HP Elliott 330 V. 200/300 RPM DC Motor with 2400 KW GE MG Set. 300 V. DC 2300/4600 V. 450 RPM 3 ph. 60 cy.
1—1375 H.P. G.E. MCF, 415 V. 1300 RPM D.C. motor with 1100 KW G.E. MG Set 415 V DC, 2300/4000 V. 720 RPM 3 ph. 60 cycle.
1—1200 HP G.E. MPC, 600 V. D.C. Motor, 450 RPM, and 1000 KW, G.E. M-G Set, 600 volt DC with 1400 KP, .8 PF, Synch. Motor 13200/6600 volt, 3 ph. 60 cy.

RE-NU-BILT BY

BELYEA COMPANY, INC.

43 Howell St., Jersey City 6, N. J.
Tel: OLDFIELD 3-3334

GUARANTEED "REBUILT" POWER EQUIPMENT

SQUIRREL CAGE MOTORS

3 phase, 60 cycle, 220 or 440 volts (2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
1250	*Al.-Ch.	ANX	3600
600	West.	CS	720
600	*G.E.	K-63455	1200
500	*G.E.	K-63455	1200
500	*G.E.	I-13-E	900
350	*G.E.	KT-559-A	1800
300	*G.E.	K6344	1200
250	*W (TE)	CS-81205	1800
250	*G.E.	KT-509-S	1800
250	*West.	CS-875-S	1800
250	Brook	R528	1200
200	*G.E.	FT-540	3600
200	West.	I-K-13B	1800
200	Brook	CSP-581-S	1800
200	*West.	RS-27	1200
200	G.E.	CS-930-A	900
200	*Al.-Ch.	KT-564-S	720
200	*West.	AN-37-G	720
200	Al.-Ch.	CS-1010	900
200	*G.E.	ARW-631	600
150	Cr-Wh	SC-140	3600
150	Al.-Ch.	AN 30-F	1200
150	West.	CSP-5815	1200
150	G.E.	I-K-15A	900
150	*West.	CS	600
125	Al.-Ch.	AR-226	1800
125	G.E.	5-Q	1200
125	Cr-Wh	K-558	900
100	W (TE)	CS-507-S	3600
100	G.E.	FT-542-Z	1800
100	Al.-Ch.	AW-23D	1200

M.G. SETS

Kilowatt	Make	Volts AC.	Volts DC
1000	West.	4000	250
750	G.E.	4160	275
500	West.	440	250
400	Al. Ch.	2300	240
300	West.	2300	250
200	G.E.	2300	275
200	Rdgwy	2300	250
150	Al. Ch.	2300	275
150	West.	2300	250
125	Cr. Wh.	4160	125
125	G.E.	2300	250
100	G.E.	2300	250
100	Al. Ch.	2300	60
60	G.E.	220/440	250
40	G.E.	220/440	250

HUNDREDS OF BARGAINS in MOTORS, GENERATORS, CONTROL, HOISTS, COMPRESSORS, ETC.

SPECIAL NEW WESTINGHOUSE MOTOR STARTERS
Magnetic, Primary resistance, Single step—3/60/—class 11-400
Size 5 Used with Squirrel Cage Motors Only 6 left in stock

SLIP RING MOTORS

3 phase, 60 cycle, 220 or 440 volts (*2300 volts or higher)

H.P.	MAKE	TYPE	SPEED
2500	*G.E.	MT (Mill Type)	257
1100	*G.E.	MT	720
1000	*G.E.	M-575-S	1200
1000	*West.	CW	450
600	*G.E.	M-6345-S	1800
500	G.E.	M-6345	1200
400	*G.E.	MTP-565	1200
350	*Al.-Ch.	ARYW	1800
300	Cr-Wh	SR-70-R	1800
250	Al.-Ch.	ARY-626	1800
250	*G.E.	I-M-17A	720
200	G.E.	I-M-16	600
200	*West.	CW1950A	514
150	Cr-Wh	SR-50R	1800
150	G.E.	I-M-15A	600
125	G.E.	I-M-15A	600
100	G.E.	I-E-13A	1800
100	G.E.	MT558	720
100	G.E.	I-M-15A	425
75	West.	CW-770	1200
75	G.E.	MT-347	1200
75	G.E.	MT-356	900
75	G.E.	MT-352	720
75	G.E.	I-M-10	600
60	G.E.	MT-356	1200
60	*West.	CW-762C	900
50	*G.E.	MT-536	1200

WRITE FOR CURRENT STOCK LIST

CHICAGO Electric Co.

ALL TYPES OF EQUIPMENT IN STOCK

1320 W. CERMAK RD. • CHICAGO 8, ILL. • PHONE: CANAL 6-3900

FOR SALE

MODERN POWER PLANTS

(Will sell complete or separately)

13750 KVA consisting of (11) 1250 KVA Rathbun Jones NATURAL GAS ENGINE GENERATORS 3/60/2400-4160V. with Switchgear.

1875 KVA TURBINE—400 PSI 700°F. Condensing, 2300 V. GENERATOR, 25000#/hr. 450 PSI BOILER; include all auxiliaries, & 25 TON CRANE.

2500 KVA TURBINE 600 PSI, Extracting 160 PSI, B.P. 30 PSI; 480 V. GENERATOR; 75000#/hr. 650 PSI Oil fired BOILER with complete accessories.

NEW BOILERS

122,500#/hr. 565 PSI @ 850°F.
44,500#/hr. 450 PSI @ 735°F.
35,000#/hr. 285 PSI @ 577°F.

Complete units including Superheaters, Economizers, Fuel Oil Burners, Soot Blowers, valves and fittings.

OTHER HIGHLIGHTS

540 KW—TURBO GENERATOR, 200 PSI 120/240 V. D.C.
200 HP—BOILERS, 160#—Stoker
175 HP C.E. Pkg BOILER, 275# Oil
6000 KVA—TRANSFORMER OISC 44000/4160 Volt
500 KVA—TRANSFORMERS, OISC (6), 66000/480 Volt
D-17000 Cat. Diesel POWER UNIT.

HEAT & POWER Co., Inc.

POWER EQUIPMENT DIVISION

40 EAST 42nd ST. NEW YORK 17, N.Y. MUrray Hill 7-5280

310 THOMPSON BLDG. TULSA 3, OKLAHOMA Diamond 3-4890

1902 COMPRESSORS 1958
WORLD'S BEST REBUILTS

138 CFM 100 psi 7x7 Ing. ES-1
140 CFM 3500 psi 12½x10 Norwalk TRS4T
162 CFM 120-500 psi 7½x13, Worth, St Booster
238 CFM 100 psi 9x9 Worth. H. B. Inges
268 CFM 500 psi 10-4½x10 Ing.
465 CFM 100 psi 12x11 Ing.
502 CFM 125 psi 12x13 Worth. H.B.
585 CFM 100 psi 15-9¼x12 Ing. XRE 3-60-4160
590 CFM 100 psi 13½-8x8 Penn DE2 3-60-220
628 CFM 100 psi 14x13 Worth. H.B.
676 CFM 100 psi 15-9¼x12 Ing. XRB—Worth.
860 CFM 125 psi 13-8x7 Joy WN102
920 CFM 110 psi 18-11x12 CP-DCE
973 CFM 25 psi 16-10x7 Ing XLE
1352 CFM 125 psi 18½-11½x8 Ing XLE
2832 CFM Vac 31x13 Ing ES
3852 CFM 100 psi 33—20½x24 Ing PRE2

AMERICAN AIR COMPRESSOR CORP.
Dell Ave. & 47th St. North Bergen, N. J.
UNion 5-4848

TURBINE & DIESEL GENERATORS

3000° KW GE · CURTIS. CONDENSING. 365# ISP. 200° FS 3/60/2300 VOLTS. NEW 1930. FULL AUXILIARIES. BARGAIN.

1666 HP BUSCH SULZER DIESEL. 8 CYL. 200 RPM. 1563 KVA WESTGHS. 3/60/2400 V. NEW 1938. FULL AUXILIARIES. EXCELLENT. REAL BARGAIN.

Other Sizes Available

WHISLER EQUIPMENT COMPANY
611 Olive St. · St. Louis 1, Mo.
CHestnut 1-4474

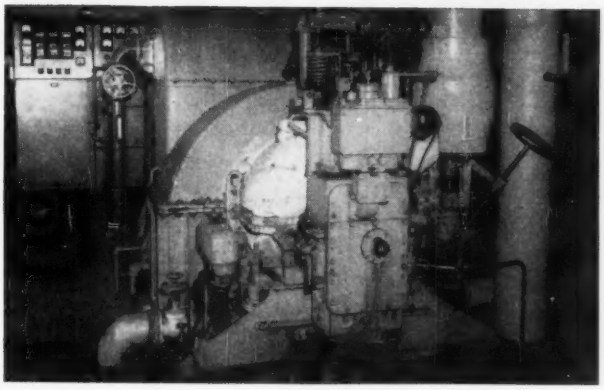
POWER PLANT MACHINERY

Turbine Generator Units
Engine Generator Units
Diesel Generator Units
Dual Fuel Generator Units
Hydro Generator Units
Gas Engine Generator Units
Synchronous Condensers
Frequency Changers
Motor Generator Sets
Rotary Converters
Package Boilers
Water Tube Boilers
Rectifiers
Transformers

INTERNATIONAL POWER MACHINERY CO.
Union Commerce Bldg., Cleveland 14, Ohio

CHARLES WEAVER – *Presents !*

2250 KVA G.E. Turbine Generator



Initial Steam—410 PSIG
750° FTT

Condensing 28" Vacuum

Electrical Conditions
3/60/2400 V.

Surface condenser
3800 Sq. Ft.

Complete Auxiliaries

Switchboard & Dual Drive Exciter

New 1944

400 Lb. Pressure 750° G.E. Turbine Generator

2500 KW @ 70% P.F.

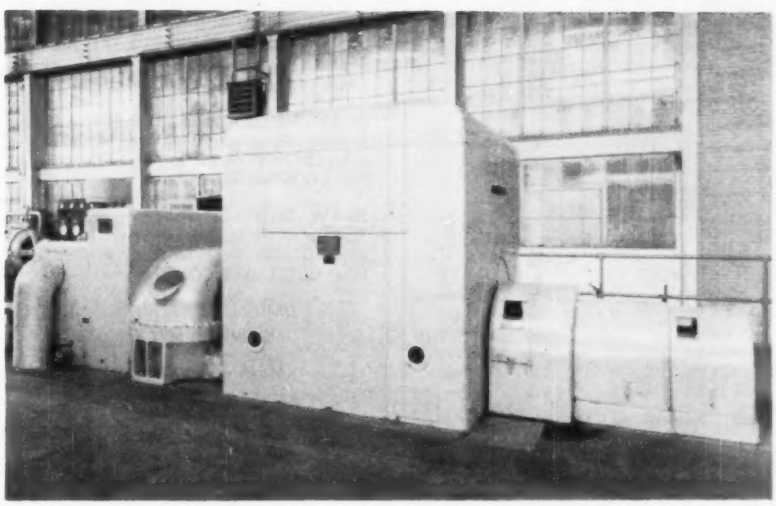
Condensing 28" Vacuum

Automatic Extraction
25 PSIG

Surface Condenser and Auxiliaries

Switchboard complete

New 1949



IMMEDIATELY AVAILABLE

A COMPLETE LINE OF BOILERS AND DIESEL ENGINES ALSO IN STOCK
Any Additional Data Desired will be Cheerfully Furnished

Cable Address:
CHASWEAVER

CHARLES WEAVER, INC.
19701 JAMES COUZENS HIGHWAY
DETROIT 35, MICHIGAN

Telephone:
BRoadway 3-1900

MISS POWER EQUIPMENT SAYS,

"For BIGGER SAVINGS and BETTER SERVICE, Get Our BARGAIN PRICES on Guaranteed New and Rebuilt Motors"

SQUIRREL CAGE MOTORS NEW AND GUARANTEED REBUILT

HP	Make	Type	Speed
400	West. S.B. Drip.	CSP-681S	1800
400	West. S.B. Open	CS	900
400	West. S.B. Splash 2300 Volt	CS-39B	720
350	A.C. S.S. Drip.	ARWW-626	3600
300	G.E. S.B. Open	IK	1800
300	G.E. S.B. Open	IK	900
300	G.E. S.B. Open	IK	720
300	West. S.B. Open	CS-1002	600
250	G.E. S.B. Open	KT	1800
250	G.E. S.B. Open 2200 v	IK-16	1200
250	G.E. S.B. Open	IK	1200
250	G.E. S.B. Open	IK	900
250	G.E. S.B. Open	IK	720
200	G.E. B.B. Drip	K-6325	1800
200	Cont. T.E.F.C.B.B.	NP-686C	1800
200	C.W. B.B. Drip	SC-86A	1800
200	G.E. S.B. Open	IK-15	1200
200	G.E. S.B. Open	IK-158	1200
200	G.E. S.B. Open 2200V	IK	1200
200	G.E. S.B. Open	IK	900
150	West. TEFCBB XP	CS-773.6	3600
150	G.E. TEFCBB	K-6328	3600
150	G.E. TEFCB XP	K	3600
150	Wst. S.S.B.Opn	CS-761C	1800
150	G.E. TEBB	K	1800
150	West. S.B. Open 2200V	CS	1800
150	G.E. S.B. Open	IK	1800
150	West. B.B. Open	CS-771C	1800
150	Ideal B.B. Open. New	A-585	1200
150	G.E. B.B. Open	KT	1200
150	Reliance B.B. Drip.	AA-5085	1200
150	Cont. T.E.F.C. B.B. New		900
150	G.E. S.B. Open	KT-558	900
150	G.E. S.B. Open	IK	720
125	G.E. TEFCBB	K	3600
125	A.C. B.B. Open	ARX-505	3600
125	West. S.S.B. Open New	CS-607	1800
125	G.E. S.B. Open	IK	1800
125	West. S.S.B. Open	CS	1800
125	El. Dyn. B.B. Drip.	KNX-22	1800
125	G.E. S.B. Open	KT-555	1200
125	G.E. S.B. Open	IK	1200
125	G.E. S.B. Open	IK	900
125	West. TEFCBB	CS-580C	900
125	G.E. S.B. Open	IK	720
125	G.E. S.B. Open	IK	600
100	Howell T.E.F.C.B.B.	K-505	3600
100	G.E. B.B. Drip	K-504	3600
100	G.E. S.B. Open	KT-343	1800
100	G.E.-B.B. Open.	K-504	1800
100	El. Dyn. T.E.F.C.B.B. XP	KNX-223	1800
100	L.A. T.E.F.C.B.B.	JX-113	1800
100	G.E. S.B. Open	KT-347	1200
100	West. SSB Open	CS-607	1200
100	West. S.S.B. Splash.	CS-770.3	1200
100	Wagner T.E.F.C.B.B.	CP-635	1200
100	Reliance B.B. Drip.	AA-5084	1200
100	G.E. S.B. Open	KT-356	900
75	A.C. B.B. Drip.	AP-444	3600
75	West. TEFCBB	CS-505	1200
75	Cont. TEFCBB	AF-109X	900

CASH FOR YOUR SURPLUS

NEW & USED Electrical Equipment

•

SEND YOUR LIST TODAY!

FREE CATALOG. This is a partial listing. We are continually changing our stock, and can fill your requirements at any time. Send for our free catalog. In Stock, fractional horsepower up to 500.

Large line of motors. Control Equipment, AC and DC Generators, MG sets and transformers. PHONE or WIRE us COLLECT

POWER EQUIPMENT CO.

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TRANSFORMERS—60 CYCLE

Qu	KV	Make	Type	Phase	Voltages
2	3000	Moloney	TCR	3	7200/6600-4160/2400
2	750	G.E.	K	1	4600-120/240
1	750	Niagara	Air Cooled	3	2400Y/4160-240/480
1	300	Penna.	(Askarel)	3	12470Y/7200-240
2	250	G.E.	H Pyranol	1	4800/3820Y/120/240
2	250	West.		1	2300/4600-230/460
3	200	G.E.	HS	1	2400/4160-240/480
3	200	G.E.	H	1	7800-15600-220/440
1	150	Eisler	OA	1	4160-240/480
1	100	G.E.	H		2400/4160-240/480
1	50	G.E.	Air Cooled	1	440/220-220/110
3	50	G.E.	HS	1	2400/4160-240/120
1	50	Amer.	Abestol	3	4160-120/208Y
5	50	G.E.	HS	1	2400/4160-240/480
4	25	West.	Hyperail	1	2400/4160-120/240

MOTOR GENERATOR SETS

Qu.	KW	Make	Speed	DC	AC
3	60	E.M.	1200	125	220 v. Syn.
1	75	G.E.	1200	125	2300/4160 Syn.
2	100	West.	1200	250	2300/4160Y Syn.
1	175	West.	1200	125	4150 Syn.
1	300	G.E.	1200	250	2300/4160Y S.B.
1	300	G.E.	1200	250	440 Syn.
1	1000	West.	720	600	2300/4160Y

ENGINE GENERATOR SETS

1—Hercules Gas HXE 62.5 KVA Westghe 3/60/480—1200

1—Wisconsin Gas (Air) PE-99 7.5 KVA Master 1 or 3/120—2200 r.p.m. NEW.

SLIP RING MOTORS

Qu	HP	Make	Speed	Type	Volts
2	40	West.	690	CW	220/440
1	60	G.E.	1800	MT	220
1	75	G.E.	600	IM	440
1	100	West.	1800	T.E.F.C. B.B.	220
3	150	Allis-Ch.	1800	AY-RW	2300
1	200	West.	514	CW	440
1	250	West.	600	CW	440
1	350	West.	1800	CW	2300
1	500	G.E.	450	MT	2200
1	500	G.E.	1200	M569Z	2300/4160Y

D.C. MOTORS—230 VOLTS

Qu	HP	Make	Speed	Type
1	75	Star	1200	SB 60 L B.B.
1	92	West.	425/1000	173 FR
1	350	G.E.	1200	Pedestal

SQUIRREL CAGE MOTORS, 3 PHASE, 60 CYC.

1—275 HP, 1180 RPM G.E. Type KT 550BS 2200V

2—200 HP, 1790 RPM, G.E. Elec. KF, TEFC, 2300V

1—40 HP, 1750 RPM Wagner 444 440V T.E.F.C.

1—25 HP, 1170 Howell 405 440V T.E.F.C.

MOTORS—SYNCHRONOUS—3 ph. 60 cy.

125 HP 600 RPM G.E. Type TS 2200 V.
125 HP 900 RPM G.E. Type TS 4800 V.
150 HP 1800 RPM G.E. Type TS 220 V.
325 HP 900 RPF West—2300 V.
300 HP 720 RPM Elec. Machinery t.e.f.c. 2300 V.
400 HP 450 RPM Westinghouse Type HR 440 V.
1000 HP 360 RPM Westinghouse Ped. Type 2300 V.

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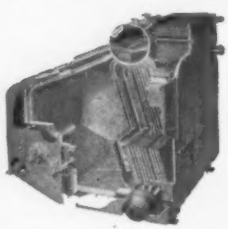

# Steam/hr.	Key	PSI	Temp.
122,500	DF	565	850
121,650	DF	565	850
60,000	SF	435	750
74,000	H	280	500
55,000	A	240	—

DF Double Furnace, SF Single Furnace (illustrated), bent water tube boilers w/economizers and superheaters, B & W's and Foster Wheelers.

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1—250, 4—150 & 2—100 KVA, 1/60/4160-120/240 Whse. Inertsen w/taps.
2—50, 6—37½ KVA, G.E. 1/60/2400-120/240 OISC.
5—25 KVA, WHSE. 1/60/2400—240/480 OISC.

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99′	3″	Sch	80 — Gr P1
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180′	8″	Sch	40 — Gr P1
23′	8″	Sch	30 — Gr P1
422′	3″	Sch	160 — Gr P2
51′	4″	Sch	120 — Gr P2
110′	6″	Sch	40 — Gr P2
67′	8″	Sch	40 — Gr P2
22′	10″	Sch	100 — Gr P2
20′	16″	Sch	100 — Gr P2
68′	2½″	Sch	40 — Gr P5
140′	2½″	Sch	80 — Gr P5
87′	3″	Sch	40 — Gr P5
200′	3″	Sch	80 — Gr P5
200′	4″	Sch	40 — Gr P5
160′	4″	Sch	80 — Gr P5
33′	6″	Sch	40 — Gr P5
25″	6″ Dble Ex Hy		— Gr P5
17′	6″	Sch	160 — Gr P5
110′	8″	Sch	40 — Gr P5
113′	8″	Sch	80 — Gr P5
12′	8″	Sch	160 — Gr P5
187′	10″	Sch	60 — Gr P5
300′	2½″	Sch	80 — Gr P11
550′	3″	Sch	40 — Gr P11
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340′	3″	Sch	160 — Gr P11
85′	4″	Sch	40 — Gr P11
600′	4″	Sch	80 — Gr P11
120′	4″	Sch	160 — Gr P11
47′	4″ Dble Ex Hy		— Gr P11
23′	5″	Sch	160 — Gr P11
70′	6″	Sch	40 — Gr P11
440′	6″	Sch	80 — Gr P11
1800′	6″	Sch	160 — Gr P11
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1070′	8″	Sch	80 — Gr P11
1345′	8″	Sch	160 — Gr P11
41′	8″ x 1.264″ Nom. Wall		— Gr P11
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95′	12″	Sch	80 — Gr P11
95′	12″	Sch	100 — Gr P11
24′	12″	Sch	120 — Gr P11
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33′	16″	Sch	100 — Gr P11
17′	24″ x ¾″ Nom. Wall		— Gr P11
68′	3″	Sch	160 — Gr P12
20′	5″	Sch	40 — Gr P12
180′	5″	Sch	160 — Gr P12
27′	6″	Sch	80 — Gr P12
31′	8″	Sch	100 — Gr P12
88′	8″	Sch	20 — Gr P12
22′	8″	Sch	40 — Gr P12
54′	10″ x 7/16″ Nom. Wall		— Gr P12
33′	24″	Sch	40 — Gr P12
225′	3″	Sch	80 — Gr P22
780′	4″	Sch	40 — Gr P22
86′	4″	Sch	80 — Gr P22
50′	6″	Sch	80 — Gr P22
46′	6″ x 1.10″ Nom. Wall		— Gr P22
330′	8″	Sch	80 — Gr P22
12′	8″ x 1.213″ Nom. Wall		— Gr P22

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HP	Mfr.	Type	Volts	Speed
800	Whse. (2)	Sq. Cage	2300	1800
700	Whse.	Slipring	2300/4000	1200
600	Elliott (2)	Sq. Cage	2300	900
500	G.E.	Slipring	2300	900
500	Allis Ch.	Slipring	2300/440	600
400	Whse. (2)	Synch.	2200	1800
400	Whse.	Sq. Cage	2200	514
400	Marathon (2)	Sq. Cage	2200	3600
400	Whse.	Sq. Cage	2300	900
400	G.E.	Slipring	2300	514
350	Br. Boveri b.b.	Sq. Cage	4800/480	720
350	G.E.	Sq. Cage	2200	1800
350	G.E.	Slipring	440	1200
350	Allis Ch.	Slipring	2200/4000	600
300	El. Machy (2)	Synch.	2200/440	720
300	G.E.	Slipring	2200/440	600
300	G.E. (2)	Synch.	2200/440	360
300	Whse.	Slipring	2300	514
300	Whse.	Synch.	440	1200
250	G.E.	Sq. Cage	2200/440	1200
250	Gen. Elec.	Sq. Cage	440	3600
250	G.E.	Sq. Cage	2200	1800
250	Whse.	Sq. Cage	2300/440	600
200	G.E.	Slipring	440	600
200	L. A. TEFC	Sq. Cage	440	1200
200	G.E.	Slipring	2200	900
200	Reliance b.b.	Sq. Cage	2200/440	1800
200	Allis Ch.	Slipring	440	450
200	Allis Ch.	Slipring	2200/440	720
200	Whse.	Sq. Cage	2200/440	900
150	Rel TEFC	Sq. Cage	220/440	900
150	G.E. (4)	Slipring	2200/440	600
150	Cr. Wheeler	Sq. Cage	220/440	450
150	G.E. (2)	Sq. Cage	2200/440	1800
150	Whse.	Slipring	220/440	1200
150	G.E.	Sq. Cage	2300	900
125	El. Machy. (2)	Synch.	220/440	400
125	G.E. T.E.F.C.	Sq. Cage	2200	3600
125	Al. Ch. TEFC	Sq. Cage	220/440	600
100	Whse. TEFC	Sq. Cage	220/440	900
100	Smith b.b. (6)	Sq. Cage	220/440	1800

D. C. GENERATORS

KW	Mfr.	Type	Volts	Speed
200	Gen. Elec.	RC	250	1450
150	Whse.	SK-184	250	1150
150	Cr. Wh.	CCD	250	650
100	Cr. Wh.	CCD-65H	125	1200
100	Reliance	651-T	600	1200
75	Gen. Elec.	CD-123	125/250	1200
60	Ideal	D	125	1150
60	Reliance b.b.	262-T	250	1200
40	Reliance b.b.	230-T	250	1200

D. C. MOTORS

HP	Mfr.	Type	Volts	Speed
300	Whse.	CB-509	250	575/1150
250	Cr. Wh.	101-H	230	1150
200	G.E. (2)	RC-38	230	1150
200	Whse. b.b.	SK	250	287/575
150	Whse.	SK-184	230	850
150	Whse.	SK-210	230	320/1000
125	G.E.	CD-173	230	575/1150
100	Elliott b.b. T.E.	JH-FE	230	1150
75	Whse. (4)	SK-163	230	500/1500
60	G.E. TEFC b.b.	CD-135	230	1150
50	Century	DX-514	230	1150/1750
50	G.E.	BF-16	230	250/1000
40	G.E. (2)	CD-93	230	1750
40	Whse. b.b.•(2)	SK-163	230	300/1200
25	Whse. (2)	SK-153	230	300/1200

MOTOR-GENERATOR SETS

KW	Mfr.	Input V	Output V
600	Allis Ch.	440 AC	250 DC
300	Whse. (2)	2200/440 AC	250 DC
200	Gen. Elec.•	220/440 AC	125 DC
125	Gen. Elec.•	2300/4000 AC	250 DC
100	Gen. Elec.	220/440 AC	250 DC
75	Star b.b.	220/440 AC	250 DC
75	G.E.	220/440 AC	125 DC
60	Allis Ch.	220/440 AC	250 DC
50	Cr. Wh. b.b. (2)	220/440 AC	250 DC
40	Ideal	220/440 AC	250 DC

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SLIP RING MOTORS 3-Ph., 60 Cy.

H.P.	Volts	Make	Speed
500	4000/2300	G.E.	900
450	440	Whse.	514
400(2)	2300	G.E.	900
400	4000/2300	Whse.	720
300	4000/2300	G.E.	720
300	2300	G.E.	900
300	440	G.E. (hoist)	600
300	440	Whse.	3600
225	4000/2300	G.E. (hoist)	600
200	2300	G.E.	600
200	2300/440	G.E.	720
150	220/440	Whse.	720
125	2300	G.E.	600

AC GENERATORS or SYN. MOTORS, 60 Cy.

H.P.	Volts	Make	Type	R.P.M.
400	2200/440	G.E.	ATI	720
300	2300/4000	G.E.	TS	720
300	2200/440	G.E.	TS	1200
200	2300/440	Whse.	G	1200
150	440/220	Whse.	G	1200
150	440/220	G.E.	TS	900
125	440/240	Whse.	HR	400

SQUIRREL CAGE MOTORS

500	2200/4000	Elliott	SC	1800
350	2300/4000	G.E.	SEDP	3600
350	2300/440	G.E.	IE-K	1200
300(2)	2200	G.E.	FT	3600
300	2360/4000	L. Allis	FS	1800
300	2300/400	G.E.	KT	600
200	440/220	G.E.	KT	1800
200	2200	G.E.	KT	1800
200	2200	Cont.	TEFC	3600
200	440/220	G.E.	KT	720
200	2200/440	G.E.	IE-K	1200
150	440	Whse.	X-prf.	3600
150	2200	Al. Chal.	KT	720
150	440/220	G.E.	TEFC	720
150	2200/440	G.E.	AR	1800
150	2200/440		KT	600
150	2200/440	G.E.	FT	1200
125	2200/440	G.E.	K	600
100(2)	4000/2300	L. Allis	OX	1200
100	2300	Cont'l.	TEFC	3600
75(2)	440	Wagner	TEFC	1800

CIRCUIT BREAKERS, 3 Pole

1—6000 Amp., Whse., 600 V., Air, New
1—2000 Amp., R-Smith, 600 V., Air, New
4—1600 Amp., DA-50, Whse., 600 V., Air
6— 600 Amp., B. Smith, 7.5 KV, Sel. oper.
1— 400 Amp., B. Smith, 7.5 KV, outdoor, New

D. C. MOTORS

H.P.	Volts	Make	Type	Speed
200	230	Cr. Wh.	CMC	1200
150	230	El. Dyn.	B/brg.	600
125	230	G.E.	CD	600
60/75	230	G.E.	CD	500/1500

MOTOR GENERATOR SETS

KW	Make	Input V., AC	Motor Type	Output V., DC
250	Whse.	440	Syn.	250
125	G.E.	440/220	Sq. Ca.	125
125	G.E.	440	Sq. Ca.	250/125
100	G.E.	2200/440	Syn.	250
75	Cr. Wh.	440/220	Sq. Ca.	240/120
65	G.E.	2200/440	Sq. Ca.	250

TRANSFORMERS 60 Cy.

1—500 kva, Al. Ch., 2400/4160Y—600 volts, 3 ph.
3—500 kva, G.E., 13800—2300 V.
3—333 kva, G.E., 2400-240/480 V.
3—333 kva, American, 2400—240/120 V.
3—250 kva, Al. Ch., 13,800—240/480 V.
1—208 kva, Al. Ch., 6000—220 V., 3 ph.
1—200 kva, G.E., 2400—120/240 V., Pyr.
3—200 kva, Mol., 13,800—2300 V.
3—200 kva, G.E., 13,800—480 V.
3—150 kva, Al. Ch., 2400—220 V.
3—150 kva, Al. Ch., 440-220 V., dry New
3—150 kva, G.E., 13,200—2300 V.
3—100 kva, Whse., 4800/2400-240/480 V., Dry
3—100 kva, G.E., 2400—120/240 V., Pyr.

GASOLINE—ENGINE GENERATOR SETS

2—35 kva, 900 R, 220 V, 3 ph. comm, LeReI, 6 cyl.
1—31 kva, 1800 rpm, 240/480 V., 3 ph., Ford, 6 cy.

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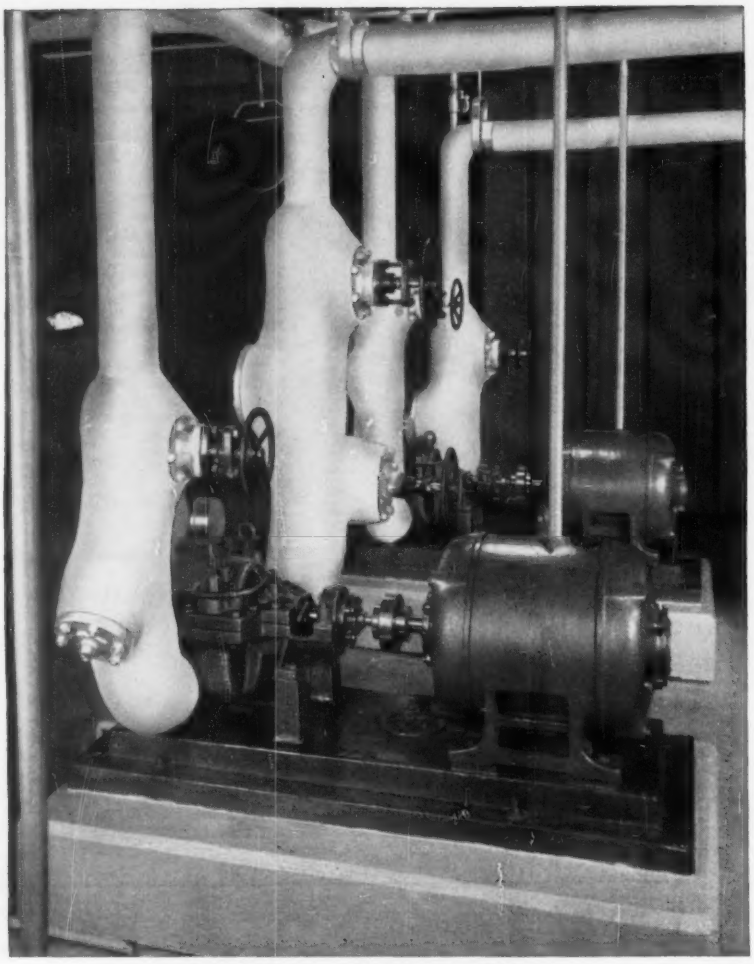


"Buffalo" Class "RR" Two-Stage Pumps

THEY PUMP MORE WATER AT LOWER COST

TESTIMONIALS from satisfied users prove the outstanding performance record of "Buffalo" Class "RR" Single Suction Multi-stage Pumps. These sturdy pumps are specially designed for high pressure and temperature clear water conditions.

The constant hydraulic balance of the "RR" design is the key to the high efficiencies these pumps deliver on the job. Rugged construction, generous bearings, extra-deep stuffing boxes — all add up to peak performance and long-lived dependability.

"Buffalo" Class "RR" Pumps are available in two and four-stage models, and in a variety of sizes to suit your needs. You will find them a best buy for any clear water service — hot or cold, at pressures up to 1500 ft. heads and at capacities from 20 gpm to 900 gpm.

Your nearby "Buffalo" Engineering Representative will be glad to show you the advantages of "Buffalo" Class "RR" Pumps — or write for Bulletin 980-E.

Every "Buffalo" product brings you the famous "Q" Factor — the built-in QUALITY which provides trouble-free satisfaction and long life.

BUFFALO PUMPS

DIVISION OF BUFFALO FORGE CO.

488 Broadway • Buffalo, N. Y.

Canada Pumps, Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

"Buffalo" PUMPS

A BETTER CENTRIFUGAL PUMP FOR EVERY LIQUID

BERGEN GETS 8 LJUNGSTROMS®
...AND SOME REMARKABLE CUSTOMER SERVICE

Public Service's new Bergen Generating Station will be served by 8 large, horizontal Ljungstroms. Almost as important . . . the Ljungstroms will be serviced *throughout* their life by Air Preheater.

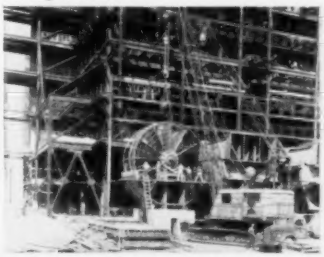
What's special about this customer service? For one thing, it's the considerable knowledge and talents of Air Preheater's engineers. They have been involved in nearly every conceivable type of boiler/preheater problem. They've seen how these problems can be handled. And they can put this experience to work for operators of Ljungstrom air preheaters.

Your Air Preheater engineer also makes regular calls to check the operation of every Ljungstrom – for as long as it's in service. (This now includes installations dating back to 1923.)

So, when you select a Ljungstrom, you're never entirely on your own. You *continue* to be the responsibility of a competent Ljungstrom engineer and benefit from his experience and knowledge. Maybe that's why 9 out of 10 preheaters sold are Ljungstroms.

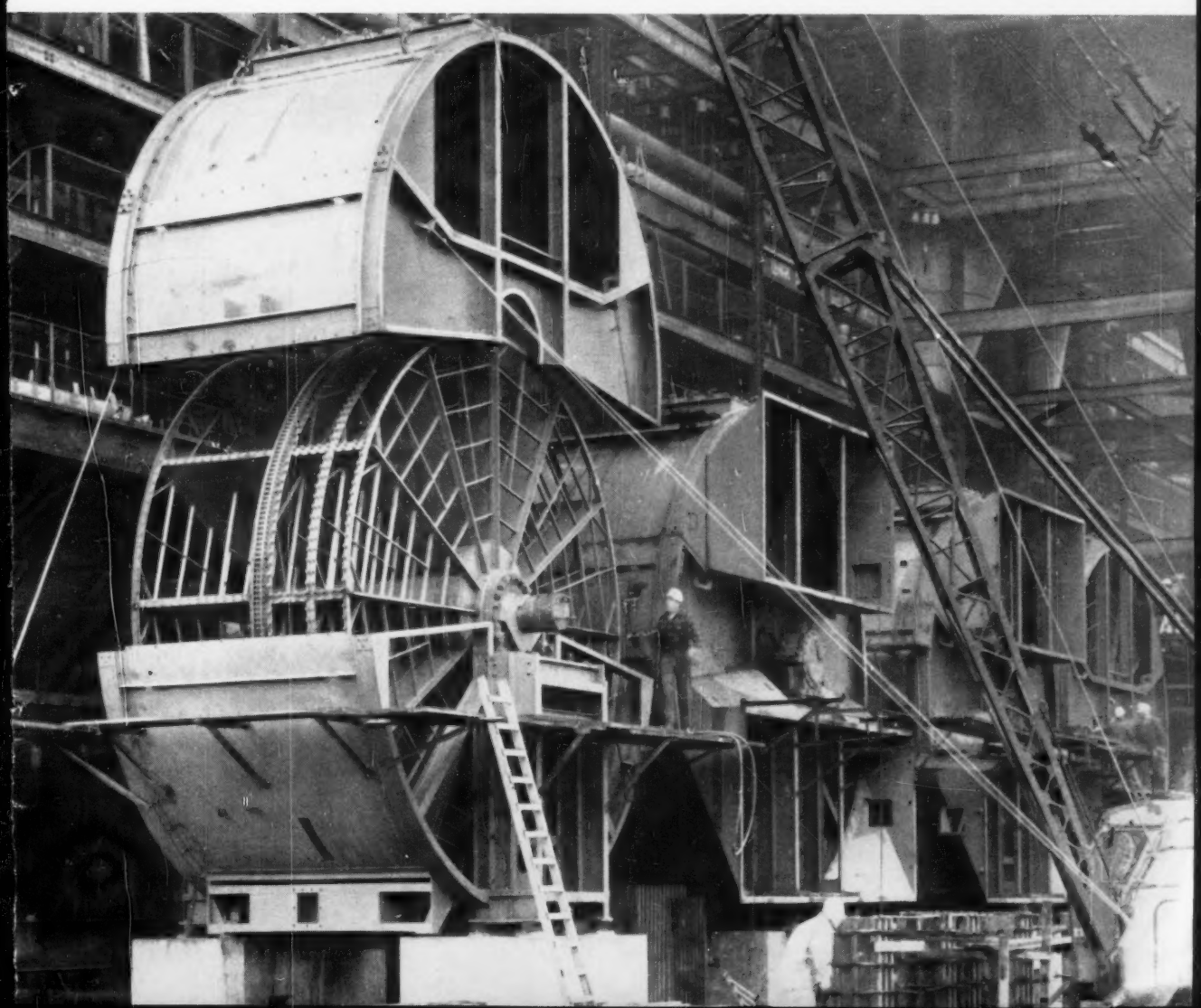
Thirty-five tons of Ljungstrom rotor being lowered into place at the new Bergen Generating Station at Ridgefield, N. J. (When the heating elements are installed the rotor will weigh 150 tons.) This is one of eight preheaters being installed by Public Service Electric and Gas Co. to serve two boilers – each evaporating 1,900,000 lbs of steam/hr. The first boiler is to be fired early next year. Anticipated preheater outlet temperature is about 275 F.

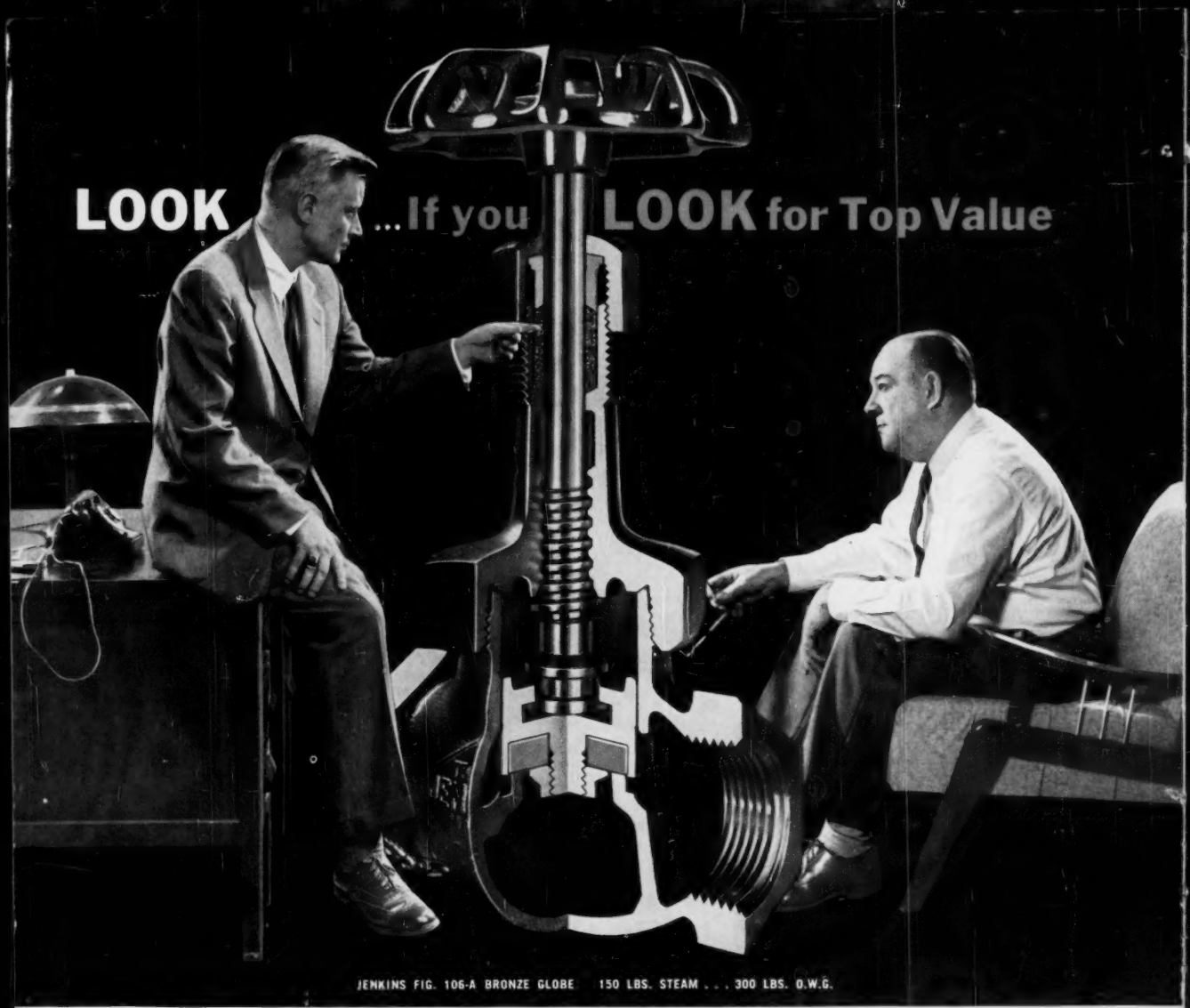
Public Service is one of the first Northern utilities to use large-size horizontal preheaters. They have nine such horizontals in operation at their Linden Generating Station and have ordered eight more for their new Mercer Generating Station.



THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.





JENKINS FIG. 106-A BRONZE GLOBE 150 LBS. STEAM . . . 300 LBS. O.W.G.

in Disc Equipped Bronze Valves

LOOK at that Wheel — Tough malleable iron. Design unequalled for cool, sure grip.

LOOK at the Index Plate — Has Fig. No. etched in green background. Held by wheel nut which is secured by rolled-over spindle end.

LOOK at that Spindle — Made of high tensile bronze. See how much heavier it is . . . how many more deeply cut threads engage bonnet. And, the crowned head that reduces friction on disc holder. Sure, it costs more to make a spindle this way. But it reduces wear, preserves packing, means easier operation.

LOOK at the Packing Nut and Gland—Note the heavy and deep bronze hex. And, that bronze gland designed to compress packing toward spindle.

LOOK at that Packing Box — Its depth equals 1½ times spindle diameter. More packing space means less repacking. An asbestos, lubricated and graphited packing is used.

LOOK at that Bonnet — One-piece, screw-over design with big hex surfaces is easy to remove. Take an extra look at the bevel joint between bonnet and body, serving as an internal brace against the crushing effect of the bonnet assembly. Millions of Fig. 106-A in use for years prove this unique design licks distortion and springing.

LOOK at the Disc Holder — It's the Slip-on Stay-on type originated by Jenkins. Correct protective depth prevents flaking or cracking of disc.

LOOK at the Disc — Easily renewed without removing valve from line. Made of compositions to suit various services . . . and **made by Jenkins,** the only maker of both valves and discs.

LOOK at that Body — Just compare wall thickness of this high tensile bronze body with any other valve. The factor of safety is many times higher than rating requires. See the curved diaphragm to protect seat from distortion by pipe strain. Note that the raised seat is higher to permit more reseating operations . . . and wider, so it won't cut into disc. Pipe threads are full length and clean cut.

LOOK at this . . . for Throttling

—Just replace the standard disc nut with this Throttling Nut and a Fig. 106-A becomes well-suited to throttling service. This unique nut reduces the effects of wire drawing and its long legs restrict flow for accurate control. Many plants take advantage of this versatile valve to reduce valve and parts inventory.

THE FIRST renewable composition disc valve was a Jenkins Valve, originated nearly a century ago. Compare today's Fig. 106-A Bronze Globe with any other. See why so many valve users agree that a *Jenkins* is still the FIRST for top value. For descriptive folder No. 189-B on the full line of Jenkins Bronze Globe, Angle and Check Valves write to Jenkins Bros., 100 Park Avenue, New York 17.

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

JENKINS SINCE 1864

Jenkins Bros.

SOLD THROUGH LEADING DISTRIBUTORS EVERYWHERE